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STEAM ENGINE PRACTICE AND DESIGN

Construction and Design of Modern Types of Connecting Rods

The construction and design of the piston, piston-rod and crosshead having been described in previous articles, the construction and design of the connecting rod will now be discussed. It is the function of the connecting rod to transmit the pressure of the steam on the piston to the revolving crank pin. To do this properly, the rod must be of such dimensions as not to bend when the maximum strain is upon it, and it must have adequate arrangements on each end for taking up the wear which occurs between the connecting rod and the wrist and crank pins.

The strain on the connecting rod is not only due to the work which it must transmit, but due to its own velocity of revolution, there is also a flinging strain which at high speeds and with long rods becomes considerable. This flinging strain is greatest near the crank-pin end and zero at the crosshead end.

Fig. 1.

To meet these various requirements, the cross-section of the connecting rod is made round, elliptical, oval, rectangular or I-shaped, the object being in the latter shapes to give strength against deflection and at the same time be as light as possible. Long rods are often made round with the largest diameter in the middle of the rod but with shorter rods it is customary to make the cross section rectangular, with the largest dimensions at the crank-pin end. The shorter the rod, the more tendency there is of the rod deflecting sidewise. For practical reasons, it is usual to make the length of the connecting rod from two to four times the length of the stroke.

At the present time almost all connecting rods are made out of forged steel. The calculations for the diameter or cross section are made on the basis that the connecting rod is a beam with rounded ends, in which case it is found that if the length of the rod is greater than 16 times the diameter, the tendency of the rod is to break by bending, but if the length of the rod is less than 16 times the diameter, the tendency of the rod is to break by crushing. This latter condition, however, seldom happens.

The different methods by which the dimensions of a connecting rod can be worked out, have given somewhat different

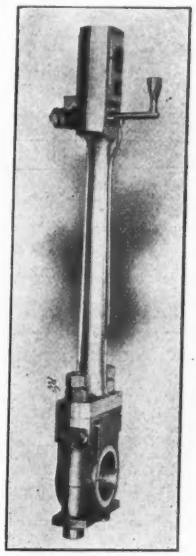


Fig. 2.

formula to be used in the design, but the following formula has been found to be the average of those given by different authorities:

$$d = .021\ D\sqrt{p}$$

in which d is the diameter of the rod in inches, D is the diameter of the cylinder in inches, and p is the maximum steam pressure in pounds per square inch. In modern high-speed engines, it is customary to make the rods rectangular in section instead of circular and to make them taper from the crosshead end to the crank-pin end. In this case, it is usual to make the

rectangular section of the same area as the round section and make the thickness equal to .63 d, between the parallel sides of the rod; the depth at the crosshead end being made equal to 1.5 times the thickness and the depth at the crank-pin end

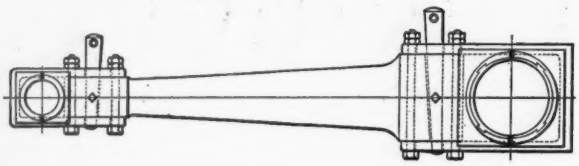


Fig. 3.

about 2.25 times the thickness. It is not necessary to have the rod so deep at the crank-pin end, the greatest strain due to its own inertia being somewhat in the neighborhood of one-third the distance from the crank-pin end. At this point it is usual to make the rod twice as deep as it is wide and for convenience carry the sides of rod out to the crank-pin end, instead of making it taper in the other direction, as is done in connecting rods of slow-speed engines.

After the dimensions of the rod have been determined, the most important feature of the design is the stub end. The crosshead pin and crank-pin being of hardened steel, the wear on the rubbing must be taken up by the arrangement of the stub end without injuring the circumference of the pins. The arrangement for doing this is called the stub end and the boxes which take up the wear are called the brasses, the wear upon which is taken up by either a gib and key, or by means of a cotter and wedge.

The brasses are made of brass, bronze, and sometimes cast iron, and are either used without a lining of bearing metal or

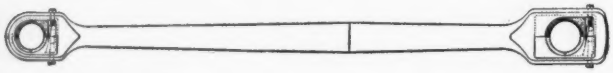


Fig. 4.

with a lining to form the actual contact surface. As these bearings wear, the lost motion is taken up by a wedge or gib which bears against one of the brasses. The brasses should be allowed to touch each other along their dividing line and as the bearing wears down, they can be filed down until the lost motion can be taken up. Sometimes liners are used to fill the gap between the brasses and when the bearing wears they can be taken out. If an opening is left between the half-bearings, there is a good chance of keying down the brass too hard and cramping the bearing, with the result that a hot bearing will be had.

The best method of describing the various forms of connecting rods is to take those used in common practice at the present time. Many years ago there were various types of connecting rods in use, each engine having a more or less different design, but at the present time there is a similarity between all of them which is very apparent and which can be seen by the following description:

The connecting rod of the Ames engines is shown in Fig. 1. It is rectangular in shape and is forged out of open-hearth steel. The crosshead end is mortised for boxes which are lined with Babbitt metal, the adjustment for which is a wedge moved by an adjusting screw on top of the rod. The crank end is of the marine type, the adjustment being made by means of lock nuts with cotter pin through bolt outside of nuts. The boxes on this end are lined with Babbitt metal, the outer half of the box being a steel casting. The connecting rod is made three times the length of the stroke. The American-Ball engines have similar forged steel connecting rods with the strap and key connection at the crosshead end, and the crank end has the marine type with removable Babbitt liners.

A type of connecting rod used on small vertical engines is shown in Fig. 2. It is made of steel forging, the crosshead end of which is made solid and machined out to receive the bronze box for the crosshead pin. The box is adjusted by a cross wedge and bolt. The crank end is also of the marine type and is made out of cast-steel. An adjustable gun-metal box is fitted into the strap and is adjusted by means of a wedge and bolt, both halves of the box being lined with Babbitt metal.

The connecting rod used on the Ball and Wood engine is shown in Fig. 3. It is rectangular in shape and is made of

Fig. 5.

forged steel; each end having the strap and key arrangement. The wear on the Babbitted boxes is taken up by the key which runs transversely, the key being held in place by a set screw.

The Brown engine has a connecting rod, as shown in Fig. 4. It is circular in section and is of the solid end type, made in one piece without straps. The crank and crosshead pin boxes are made of phosphor-bronze, Babbitt lined. The adjustment is made by means of wedges and so arranged that when wear is taken up, the effective length of the connecting rod is not altered. The connecting rod used on the Brown-Corliss engine is very similar to that shown in Fig. 4. The connecting rods are round with solid ends, the crank-pin boxes being Babbitted, while the crosshead pin boxes are made of phosphor-bronze. Instead of taking up the wear, as shown in Fig. 4, the wear is taken up by a side wedge, which has full bearing on the box and solid end of rod.

The Bates-Corliss engine formerly used a style of connecting rod shown in Fig. 5. Like most engines which belong to

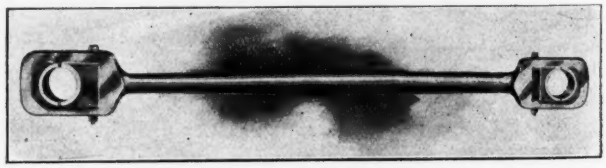


Fig. 6.

the older type, the connecting rods were made out of wrought-iron. As shown in the figure, the crank end is provided with strap, gib and key, the key having a nut and washer on lower end to bind the strap to rod. The crosshead end is of solid box form and the brasses are adjusted by a wedge on the inner side, the arrangement maintaining a constant length of connecting rod. The later Bates connecting rods are shown in Fig. 6. They are made of steel forging with solid ends, the

boxes being adjustable by wedges and adjusting screws.

The Chandler and Taylor high-speed engines use rectangular, solid end connecting rods, the crosshead ends of which are provided with bronze boxes and crank-pin ends with brass

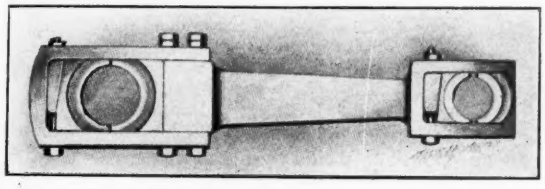


Fig 7.

boxes, Babbitt lined. The take-up is on the same side of the pin at each end of the rod, which maintains a constant centre to centre distance between pins.

The Erie City engines use rectangular connecting rods, the crosshead end being of solid construction and crank end having a strap held in place by two bolts. The adjustment for wear on each end is by means of wedges, held in place by set screws. The boxes on the crosshead end are bronze and the boxes on the crank-pin end are bronze, inlaid with Babbitt

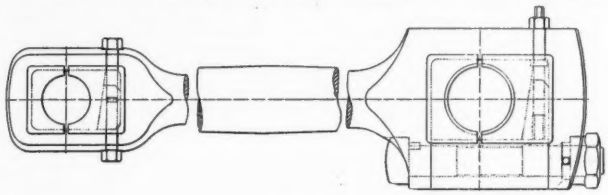


Fig. 8.

metal. The connecting rod on the Erieco engines, shown in Fig. 7, are very similar.

There are two kinds of connecting rods used on Harris-Coliss engines. On engines which have a cylinder smaller than 24 inches, the solid-end type will be found, but on large engines above 24-inch diameter of cylinder, the hatchet-end type is used, as shown in Fig. 8. By this arrangement, when the bolt is removed from its position, it allows a side of the strap to be taken out, so that the rod can be easily lifted off the pin. The adjustment of the boxes is made by means of concealed wedges, set up by adjusting bolts, so placed as to always maintain the original length of the rod. The connecting rod used on the Leffel engine is shown in Fig. 9. The crosshead end is solid while the crank-pin end is provided with

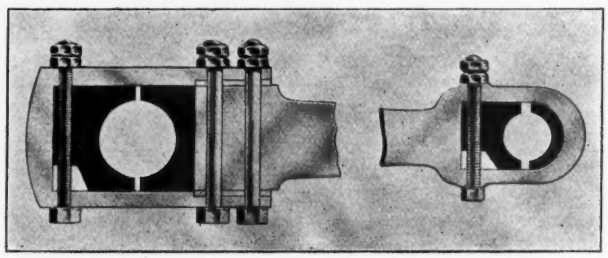


Fig. 9.

a strap, adjustment being made on the same side of the pin for the usual purpose.

The connecting rod used on the larger sizes of Westinghouse vertical engines is shown in Fig. 10. It is made of forged-steel, to the lower end of which is fitted a horseshoe strap. This strap is not adjustable but is held rigidly in place by two tap bolts passing entirely through the stub end of the rod and threaded into one side of the strap. In the bottom of the strap a semi-circular bronze liner is fitted and above this there is a bronze box lined with Babbitt metal. This box is kept in place sideways by flanges which embrace the sides of the strap and rod. Since this type of engine is single-acting, it is not considered necessary to use refined methods for taking up the wear; instead, when lost motion becomes unusually large, it may be taken up by inserting between the top of the box and the stub end of the connecting rod, one or more pieces of thin sheet steel, known as shims.

All connecting rods used in modern engines belong to one of the types described above, the only difference being perhaps some slight deviation in the method used for keying up the brasses. From the above description it will be noticed that

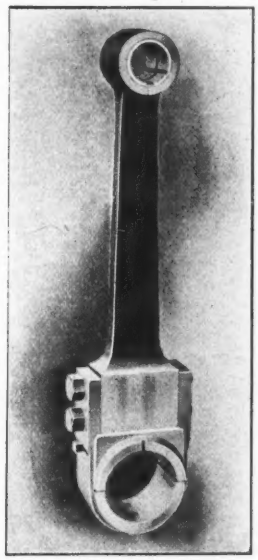


Fig. 10.

without exception all modern engines use steel connecting rods, high-speed engines use rectangular rods tapering from crosshead to crank end and most slow-speed engines use circular rods with the largest diameter about the middle. In the smaller types of engines and on many high-speed engines, the marine type of rod is used on the crank end, while modern slow-speed engines are doing away with the old strap form of rod and are using rods which have solid ends, the adjustable key being used to take up the wear.

Economy in Engine Performance.

The highest economy in engine performance requires that the steam shall be admitted at a uniform pressure as near that of the boiler as possible; that the cut-off shall be sharp and quick, so that expansion may take place over the requisite range and that the steam shall be discharged completely after expansion with the exception of just enough to cushion the piston at the end of the stroke. Both admission and exhaust valves must open wide and very rapidly. Excessive friction in operation of the valve mechanism is to be avoided not only on account of the loss of power but also on account of the additional wear and tear.

Central Station Practice in Germany and Austria-Hungary

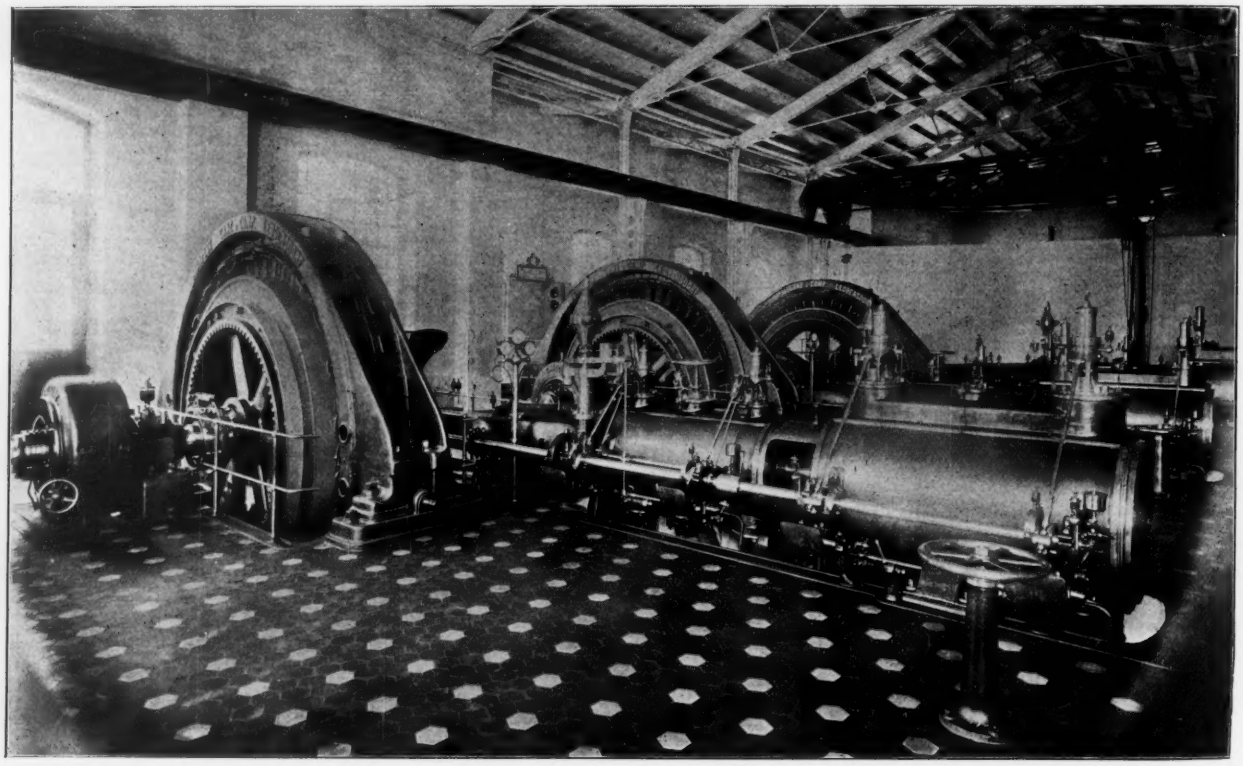
By Frank C. Perkins.

Among the first electrical stations installed using direct-connected dynamos were those of Germany and Austria-Hungary. Many plants were in operation in these countries with direct-connected alternators as well as continuous current machines, while in America belt-driven generators were used almost entirely. The electrical and mechanical engineers of Germany and Austria-Hungary started in with their first installations, using horizontal tandem and cross compound engines directly coupled to electrical generators and they have adhered almost exclusively to these types up to the present time. The accompanying illustration and the illustration on front cover show the direct-current generators and the alternators driven by these types of engines in the Budapest central station and in the municipal power station at Trieste. While large flywheels are provided in the former station for aiding in the speed regulation where direct-current machines are utilized, the revolving field of the alternators in the latter station provides all the flywheel effect necessary. The dynamos of the Trieste station are 240 kilowatt three-phase machines, supplying current at 2000 volts pressure and a frequency of 42 periods per second. The steam engines are of the tandem compound type and drive the alternators at 110 revolutions per minute.

In Germany and Austria-Hungary horizontal engines have been utilized almost exclusively in the past, but during recent years high-power slow-speed vertical engines have been finding their way into Continental central stations, although these types are probably more extensively used in America and England. High-speed engines have, without doubt, been more highly developed in England than in any other country, and this type insures an engine as well as an electrical generator of much lower cost than the slower speed units.

The central station at Tilsit, Germany, shown in accompanying illustration, is a good example of a German central station using horizontal tandem compound steam engines driving direct-current dynamos with a flywheel for aiding in speed regulation.

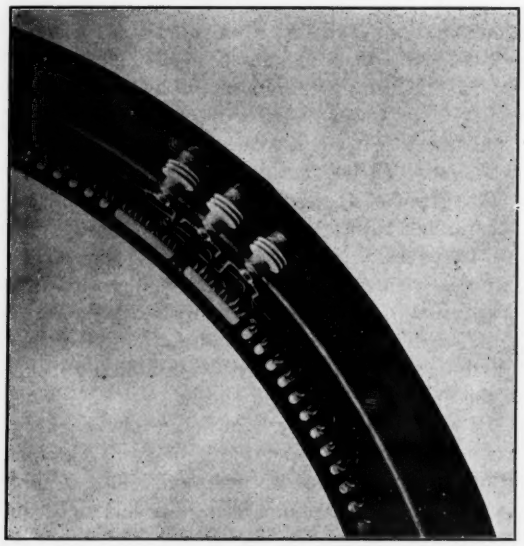
The tendency in modern central station practice at the present time is towards higher voltages generated directly in the alternators without making it necessary to use step-up transformers for high tension power transmission. Alternators are now constructed for supplying from 10,000 to 15,000 volts direct from the armature windings without the machines giving any trouble whatever, some of these machines having worked without any interruption for several years. The accompanying illustration shows a portion of a Lahmeyer armature, a type much used in Europe. In case of low voltages, the coils consist of massive copper bars, whereas in case of high tension, well insulated copper wires are used. The casing is fixed around the entire armature for protection, as shown, so arranged as not to interfere with the ventilation of the machine.



240 K. W. Three-Phase Generators driven by Tandem Compound Engines at the Trieste Municipal Power Station

The armature coils are drawn through completely closed micanite tubes, so that a breakdown of the insulation under normal conditions is practically impossible. The coils where projecting out of the armature frame are wound over templets in such a way as to prevent a breakdown between one coil of one phase and one coil of another or between one coil of any phase and the frame of the machine. Crossing of the wires is as far as possible avoided and the coils, besides the above insulation, are wound with insulating tape.

The alternators in modern central station practice have armatures which are fixed, consisting of heavy cast-iron frame, built according to the size of the machines in one, two, or several parts. The frame of the alternator rests on a base plate, as in the case of the Lahmeyer machine, on which are fixed slightly conical adjusting plates, enabling the frame to be moved in any direction. In the case of large machines, the frame is usually provided with extra strengthening pieces and the extra stiffness of this arrangement reduces the vibration to a minimum, so that the machines work practically noiseless. The armature core consists of iron plates, insulated by means of prepared paper, slots being stamped in the inner periphery of these plates. The regulation of voltage of the alternator is

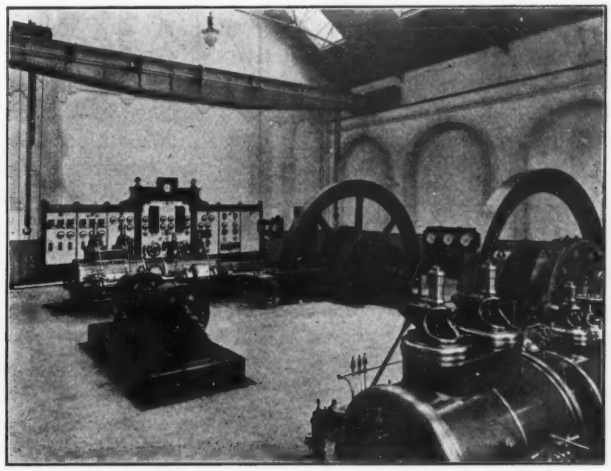


Portion of a Lahmeyer Armature showing Casing and High-Tension Insulators

entirely effected by means of the regulation in the shunt circuit of the exciter without any appreciable loss of energy.

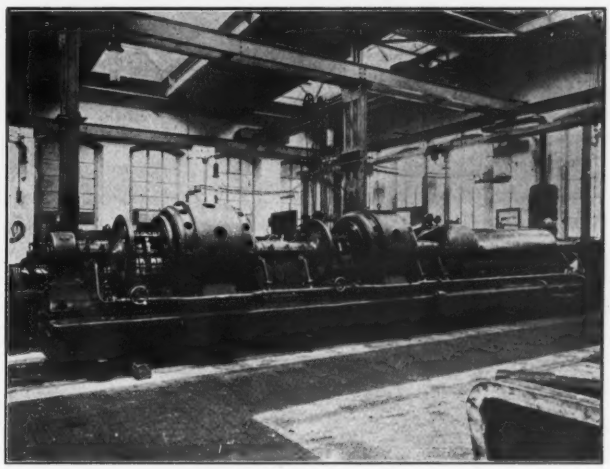
The introduction of steam turbines in the modern central station means, of course, greatly increased speed of alternators which are directly coupled to the turbine shafts and a reduction in the size and first cost of the alternators. The accompanying illustration shows a double dynamo unit operated by a 750 horse power Parsons steam turbine at Bremen. Another steam turbine installation at Bremen is at the power plant of the Norddeutcher Lloyd, where at 450 horse power steam turbine is directly coupled to a 300 kilowatt electrical generator. When this dynamo is operating at full load, the steam consumption is 23.7 pounds per kilowatt hour without the use of superheated steam, the pressure at the steam turbine being 150 pounds. With the generator operating at one-half load, the steam consumption of the turbine is 27.7 pounds, while at three-quarter load the steam consumption is 24.9 pounds per kilowatt hour.

At the power station at Frankfort, a 4000 horse power steam turbo-dynamo of the Parsons system was installed and a test was recently made showing a steam consumption of 15.9 pounds per kilowatt hour with the steam turbine working at a



Central Station at Tilsit, Germany

pressure of 190 pounds and 556 degrees Fahr. superheat, the alternator generating a load of 1945 kilowatts. This alternator has a normal capacity of 3000 kilowatts and was guaranteed to have the above steam consumption for the turbine when operating at 2600 kilowatts, the pressure being 130 pounds and the temperature of the superheated steam 540 degrees Fahr. The alternator supplies a current of 3000 volts pressure when driven at a speed of 1360 revolutions per minute by the turbine. The length of the turbine is 54 feet, its width and height being 8.2 feet. When tested at practically full load, the gen-



Double Dynamo Unit driven by a 750 H.P. Pa.son Turbine at Bremen, Germany

erator having an output of 2995 kilowatts and the steam turbine operating at 160 pounds pressure and 560 degrees Fahr. superheat, the steam consumption was found to be 14.75 pounds per kilowatt hour. When the generator was supplying 2518 kilowatts with the superheat temperature 530 degrees Fahr. and the steam pressure 190 pounds, the steam consumption of the turbine was 15.6 pounds per kilowatt hour.

THE STEAM TURBINE PROBLEM

The Latest Report on the Operation of the Two Hundred and Twenty-four American Turbines Now in Use

During the past few years, the growth of the application of the steam turbine, especially in electric light plants in this country, has been of the mushroom order. Here, there, and everywhere, the hum of the revolving turbine began to be heard in place of the synchronous noise of the reciprocating engine. So rapid were the accounts of new turbine installations that it seemed as if a turbine tidal wave had struck the country and was about to wash the reciprocating engine from its foundations.

There were several reasons for this. Theoretically, the steam turbine is the ideal steam motor for transforming the pressure of the steam into useful work, and considering the number of tests made upon new turbines, the results in practice seem to bear out what theory indicated. Besides its apparent greater economy of steam consumption per kilowatt output, the steam turbine also has features of operation which make it very attractive. Another and perhaps one of the main reasons why steam turbines were being installed so rapidly was because two of the largest electrical companies manufacture two of the best-known types of turbines in use today and conditions were such that many electric light plants installed the turbo-generator unit without question.

Within the past year, however, murmurs of complaint have been heard—suppressed to be sure—that all was not always well in the interior of the turbine and that certain things were happening which did not ease the mind of the operating engineer, who always feels the aches and pains of his engine.

It was natural, therefore, that some closer attention be given to some of these complaints and the National Electric Light Association, which is a representative body of most all the large electric companies in this country, last year appointed a committee, consisting of W. C. L. Eglin, chief engineer of the Philadelphia Electric Co., chairman of the committee, A. C. Dunham, I. E. Moultrop, George W. Cato, and J. D. Andrew, to investigate the turbine problem.

This committee reported the results of their observations at the recent meeting of the National Electric Light Association held at Denver, Col. They reported that there are now 224 American-built turbines of over 350,000 horse power capacity in operation, of which four are 5500 kilowatt machines, ten are 5000 kilowatt, four are 3000 kilowatt, thirteen are 2000 kilowatt and nineteen are 1500 kilowatt. Information concerning the operation of 59 of these installations was furnished by the owners, and as was to be expected, although the committee made a special effort to obtain a complete state of troubles due to the use of turbines, very little data of this nature was available.

One electric light company, operating Curtis turbines, reported one shutdown caused by a worn bearing on the tachometer drive vibrating rod operating the latch on the emergency stop valve. This resulted in the emergency valve closing suddenly without any warning. The same company also reported slight trouble with the generator, due to loose laminations in the armature. The latter trouble was discovered and remedied before any damage was done.

On another Curtis turbine, the users experienced some little difficulty with the needle valves and the main nozzle valves, due to warping caused by the high degree of superheat used in the plant. On another Curtis turbine some trouble was experienced from air leakage in the turbine and also from water mixing with the oil lubricating the step bearing. The company operating the above Curtis turbines also states that it had some trouble with the condensing apparatus, but omits to state just what the trouble was.

On a De Laval turbine, one electric company reports some trouble due to design of the brush holders on the dynamo, which was easily remedied. On another De Laval turbine, trouble was reported with the oiling. This seemed to be due to the filling up of the spiral oilways which stopped the flow of oil and was overcome by the use of special oil carefully filtered.

The few Parsons installations that reported seem to have had various troubles. One company using Parsons turbines reported some difficulty in the matter of lubrication. The oil, which worked well in one part of the machine, solidified into a jelly and failed to work in some of the other bearings. On another Parsons turbine, trouble was reported due to the repeated cutting out of the throttle valve seat, which tended to cause the turbine to race on light loads. This difficulty was attributed to the peculiar water used in the locality. They also report trouble from excessive vibration of the turbine, caused by the expansion of the exhaust pipe throwing the turbine out of line. This developed some months after the turbine was started and was entirely corrected by installing an expansion joint in the exhaust pipe.

Two Parsons turbines are reported to have encountered trouble with the field coils of the generator, both machines burning out under less than normal load. This is apparently due to an error in the design. They have had some difficulty with the breaking of the brass sleeves of the concentric bearing. They also report that they find it necessary to give the lubricating system special attention to avoid trouble with it.

One report has been received on a Parsons turbine stating that a large number of the blades were lost because the turbine was started too quickly. Superheated steam was being turned on and sufficient time was not allowed in warming up the machine to maintain proper clearance between the tips of the blades and the casing. On another Parsons turbine trouble is reported from many of the blades of the rotor breaking while running and without rubbing. Another company, operating several Parsons machines, reports it has had a few blades broken out of one of its turbines due to some foreign substance being carried into the turbine through the steam pipe. This did not affect the operation of the turbine, which was continued in service until it was convenient to shut it down and repair it.

That everything has not been as satisfactory as steam turbine people would have one believe is indicated by the changes

in the design of the buckets and materials out of which they are now being made. The committee's report as regards two of the best-known turbines and the effect of high vacuum, leakage of air, condensers and carbonization of oil is as follows:

Curtis Turbine.—In visits to the General Electric Works the committee discussed with the engineers of the company the use of the mechanically operated valve in place of the electrically operated valve, which is at present the standard practice. One mechanical type, operated by power transmitted from the turbine shaft by means of a worm wheel and gearing, was designed by Mr. Richard H. Rice, and follows closely the best lines developed from engine experience. The other mechanical type is operated hydraulically, a water piston giving reciprocating motion to a rod controlling a bank of valves that are opened by means of a cam and closed by a spring. The governor controls a pilot valve which in turn operates the hydraulic piston, the motion of which is transmitted to the cams that open the valves. In the first case the valves are thrown open or closed, and in the second there is a throttling action of the valves. The one objection to be raised to the mechanical form of valve, the committee states, is that it necessitates the use of a small number of valves of large area, and some criticism has been raised that the regulation of the turbine will not be so good with that type of valve as with the larger bank of valves of smaller diameter that are electrically operated.

The committee reports that a decided improvement has been made in the electrically controlled valves by placing the springs and stems outside of the casing, and in certain details in the construction of relays and pilot valves. The latest type of electrically operated valves appears to be working satisfactorily. The throttle valve and emergency stop formerly used on the Curtis turbine were not considered satisfactory. Improvements have been made and the gate valve has been superseded by a double-seat, balanced globe valve with emergency stop attachment.

The brake applied to some of the earlier types of turbines has been abandoned, and is not considered part of the standard machine. It has been found in practice, however, that the brake was useful in holding up the weight of the revolving parts when repairs or examinations were being made on the machine, and the company was asked to take under consideration the advisability of adopting on all of the larger sized machines an attachment similar to the brake for this purpose, and they will furnish in the larger sizes such an attachment as part of the standard machine when so specified.

There are various opinions held as to the maximum clearance allowable in this type of turbine without interfering with the efficiency, but the view now held by the General Electric Co. is that the amount of clearance imposed by the mechanical conditions does not in any way affect the efficiency of the turbine. This is especially true of the four-stage type of machine.

The most important advances made in details during the year, the committee states, were changes in the construction of the wheels so as to form a smooth surface by the removing of all bolt heads and ribs, bolts being substituted by countersunk rivets, thus reducing the friction of the revolving parts. Important changes have also been made in the shapes of the buckets and in the construction of the nozzles. These changes have all been made with the object of improving the economy of the machine. Step bearings are now being operated with water instead of oil, and the construction has been modified to admit of this change. The committee has been unable to find a single case where the step bearing has given any serious trouble.

Westinghouse-Parsons Turbine. — The committee reports that the type known as the two-stage has been dropped. This was really not a two-stage turbine, but the wheels of larger diameter were placed in a separate casing, by which, at that time, it was thought some advantage could be gained in economy by reheating the steam between these two stages. It was found in the experiments this could not be accomplished, and as it was more expensive, it was dropped. Now all the sizes are practically on the same line, merely increasing in size to provide capacity, with the exception of certain sizes operating at lower speeds, in which the diameter of the wheeels is very much increased. Particular attention is now being given to the blades, and some of the machines now being built have steel blades, and some blades of various alloys.

The most important improvement in the construction of the blading, the committee states, is the addition of a flat lace of steel which is threaded through openings near the outer edge of the blades and fastened by twisting the flat steel lace between each blade. This performs two functions: first, it maintains a uniform spacing between the outer edges of the blades; and, secondly, it increases the mechanical strength of the blades and prevents vibration. In the larger sizes the longest blades are made from drop forgings with special ends which are machined so as to fit in a dovetailed groove and fastened at the outer end by means of the band lacing previously described. The joint in the lacing is made by introducing a second lace nearer the shaft, the blades at the joint having two holes punched, and a short piece of wire is arranged at the break of the outer lacing strip to lap the joint. Tests have been made to see whether this band strip in any way affects the efficiency. Thus far, however, these bands have not shown any change. It is expected that this lacing will overcome most of the trouble that has been experienced in the failure of blades.

Some minor changes have been made in the oiling system. The old system of oiling was to pump the oil through cooling coils to a tank arranged above the turbine to obtain a static head of two or three feet of pressure on oil bearings. This has been changed to a closed tank, and a pressure is maintained in the tank of about seven pounds by means of a by-pass valve controlled by the pressure on the tank. This change was made on account of insuring constant and liberal flow of oil on all bearings without largely increasing the size of the storage tank.

The company is experimenting with a double-flow turbine in which the steam is admitted at the centre and expands through the turbine to the outer ends, being connected at the exhaust opening to the condenser. This has a number of mechanical advantages. First, it obviates the necessity of connecting pipes through balancing pistons and various pressure points, it shortens the length of the shaft, and more than doubles the capacity of the turbine of the same length. The machine is merely in an experimental stage, and sufficient tests have not been made to learn whether the economy is as good as that of other types. It possesses a number of features, however, that appear to the committeee to be worthy of mention and form an index of the possible future developments of this type of turbine.

Other Turbines.—The Hamilton-Holzwarth machine of the

Hooven-Owens-Rentschler Co., the machine of the Allis-Chalmers Co., the De Laval turbine and the Zoelly turbine of the Providence Engineeering Works are not discussed at length by the committee, owing to lack of information concerning the operation in service.

High Vacuum.—The committee lays much stress on the importance of a high vacuum, pointing out that while a reciprocating engine's use of vacuum is limited by the capacity and efficiency of the low-pressure cylinder, the turbine is prepared to make full use of steam down to the lowest point of vacuum obtainable. Quite a number of experimenters have made tests to determine the economical effect of an increased vacuum, and it is interesting to note that these results approximate fairly close to each other. The committee reports a number of tests, including some of its own, and reaches the following conclusions as to the value of high vacuums. It assumes a 2000 kilowatt unit working at an average load of 1500 kilowatts for 15 hours per day, coal at $3, evaporation 9 pounds, steam consumption 22 pounds per kilowatt. A rise of vacuum from 26 to 28 inches may be assumed to increase the economy about 6 per cent., the committee estimates. The water thus saved will be 140,000 cubic feet, worth at $2.58, a total of $35, and the coal saved will be worth $1500. This makes a total saving of $1535. The condenser plant for a 28-inch vacuum will cost $5000 more than one for 26 inches; interest, depreciation and other fixed charges on this sum will be 17 per cent., or $850. This does not include the extra cost in steam to run the larger auxiliaries, but inasmuch as such exhaust steam would return a benefit to the feed water if they were all steam-driven, the committee assumes that the extra cost in water is 2 per cent. of the total required by the turbine, and is worth $12 a year. Hence the total net saving is $673, which, at 5 per cent., represents a capital saving of $13,460 due to the higher vacuum.

Leakage of Air.—An important feature of operation with high vacuum is the necessity of having air-tight stuffing boxes and pipe joints, lack of which results in loss of economy to the turbine and increased consumption of steam by the dry-vacuum pumps and circulating pumps. The committee suggests the following as some of the remedies:

All joints after being made up can profitably be gone over with any heavy homogeneous paint (this preferably should be done when working under vacuum), such as black asphaltum, or shellac and red lead, both of which dry readily. This is a simple remedy and when carefully applied is very effective. There often is considerable air brought into the feed water at pumps and open tanks, and it is desirable to work the water of condensation on a closed system, or, when an open system is used, to arrange that the water is as little stirred up as possible; liberation of entrained air might be assisted by the use of steam coils in the bottoms of tanks.

In pressure pipes when velocity of the water is slow, it is possible to trap off considerable air by the use of a stand-pipe communicating with the feed pipe by a narrow slot and having at the top a float-actuated snifting valve.

Unless close supervision is used to see that lazy or indifferent engineers do not cover up the existence of air leaks by pushing their air and circulating pumps at a greater speed and power than would be necessary with tight joints in exhaust piping, condensers and stuffing boxes, the operating costs can be very appreciably added to in a manner that often defies detection. Connections from turbine to condenser and condenser to pumps should be as short as possible, to avoid the chance for leaks and consequent uneconomical operation.

Condensers.—Where a surface condenser is of the counter-current type an independent air cooler appears to be an unnecessary expense and care if the condenser cooling surface is of the proper amount. In the parallel-flow type, however, an air cooler is undoubtedly of considerable benefit in reducing the tension on the air and non-condensable vapors.

Many types of condensers are laid out with a solid bank of tubes presented to incoming steam. Naturally the steam has to seek its way between the tubes to get to the body of condenser, and in narrow condensers the net area between tubes of each layer may be even less than the area of exhaust pipes, and consequent velocity of the steam through these passages may mount into tens of thousands of feet per minute. The desire in a condenser should be that the incoming steam would immediately spread out over the whole cooling surface in its proportionate amount, otherwise only a limited area of surface will be devoted to the act of condensing and the remainder to cooling down condensed water. Very good results have been obtained toward increasing the efficiency of condensers by opening channels between tubes equal in aggregate area to the exhaust pipe and extending somewhat beyond the centre of the tube nests. The benefits were manifested in an increased vacuum with the same amount of cooling water and a radical decrease in the tendency of the vacuum to drop under overloads. These channels also offer a greater entrance area into the body of the tubes, by way of the interstices between the tubes forming the sides of the channels.

The committee recommends that on all new contracts purchasers insist upon adequate means of inspecting the ends of tubes and for obtaining admittance to the condenser above and below the tubes. All openings should be made to accommodate the entry of a man wherever possible. This detail is naturally one of operation in which operating engineers are especially concerned, as it has to do with labor costs for repairs. It has the further economic value that any piece of apparatus that is easy to inspect is going to be maintained in a more efficient condition than one on which overhauling is a difficult matter.

Undoubtedly the best arrangement of the condensing plant, the committee says, is the use of a counter-current condenser placed as close to the exhaust nozzle as possible and with the dry-air pumps drawing from the condenser at the point of coolest circulating water; this pump is also so placed that the minimum of pipe connection can be used. With this arrangement the possibility of air leaks would be greatly reduced, the quantity of circulating water would also be lessened owing to the lower tension of the air which has just left the coldest tubes of the condenser.

Carbonization of Oil.—Considerable trouble has been reported from carbonization of the oil in the air cylinders of the dry-air pumps. This has led in some instances to the use of a high grade of mineral oil especially produced for use in air compressors. There have also been reports that this has not cured the trouble. While the temperature in the cylinder does not rise to an excessive amount, yet if a temperature could be maintained below a possible critical point this trouble might be eliminated. The simplest way to do this would seem to be to jacket with cold water the valve casing and covering over

which the hottest air, that of compression, is continually sweeping. The metal surrounding the ports in the cylinders is perhaps the greatest accumulator of heat, and if these port passages were cast with walls no thicker than necessary, further supplemented by cooling water, the trouble would be minimized. An inter-cooler between cylinders of a two-stage pump would also be of very considerable benefit both as to decreasing carbonization and as to increasing the efficiency of the air pump; the remedy used by one correspondent, where he boiled out the air cylinder once in two weeks' time with caustic soda, was very aptly called by himself, "a nuisance."

Relief Valves.—Atmospheric relief valves are undoubtedly to blame for some of the air leakage into the condensers. Where the vacuum is of so great importance, as in turbine work, it will undoubtedly pay to go to further refinements in the design of these valves in the endeavor to secure automatically absolute tightness. It is common practice to use a water seal on these valves, but there is seldom provision made to insure that it is always maintained. It may either be no seal at all or the exhaust pipe full of water. It should be possible, now that the use of oil has been done away with by the turbine, to replace the present brass seats on valve body and disc with hard rubber. Rubber would be flexible enough to take up any inequalities in the seats due to machining or to distortion from heat and the strains of the large exhaust piping. The usual present design of relief valve does not allow of ready inspection, thereby offering but another excuse for the engineer to "let her go" until he cannot escape criticism from even the most obtuse layman.

METHODS OF REPAIRING VALVES

By W. H. Wakeman.

Some time ago, a man who had worked in steam plants for several years, applied to me for a recommendation as engineer for a certain plant in which scores of valves were in constant use. As it was part of the engineer's duties to keep these

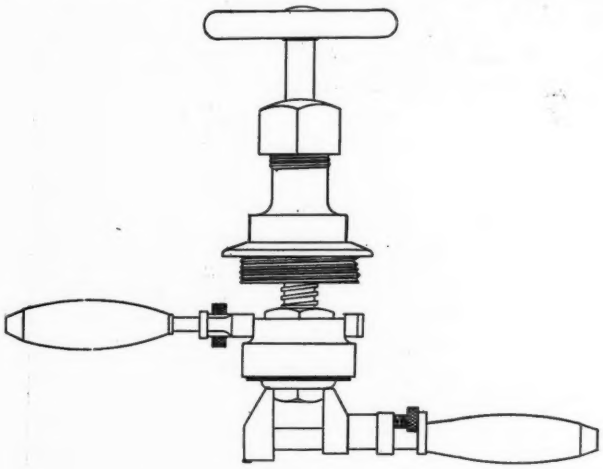


Fig. 1.

valves in repair, I asked this man to explain how he would proceed to repair a Jenkins valve. He explained the usual method employed for grinding in an all-brass valve as a suitable reply to my question, which, of course, proved that he did not understand the construction of the most common and easily understood part of a steam plant.

Numerous cases can be cited where engineers claim to have put new seats in valves, when they have only renewed the discs. These are my reasons for presenting the following illustrations and descriptions:

Fig. 1 shows a very good plan for renewing a disc in a Jenkins Brothers valve. The bonnet is unscrewed by applying a large monkey-wrench and giving it a sharp, quick pull to loosen the thread. A large one is recommended because it will not spring easily and round off the corners of bonnet. Where a valve has been used for a long time under steam pressure, it may be difficult to remove the bonnet, making it necessary to apply a Stilson wrench to do the job, but this is not recommended unless it cannot be done with a monkey-wrench. Marks made by its teeth should be carefully removed by filing.

The illustration shows a way for holding the disc-holder with one wrench while the nut is unscrewed with another. In some cases the nut and disc will come out together, but if not, the latter may be softened by holding it in a gas flame, when it may easily be pried or cut out, and a new one put in. The lower wrench should be turned over, and the nut screwed down with a monkey-wrench, as shown. If a prick punch mark is put into the edge of threads it will prevent the nut from working off easily.

When piping a shop or mill, or making repairs to the steam piping system, the bonnets of all valves should be removed

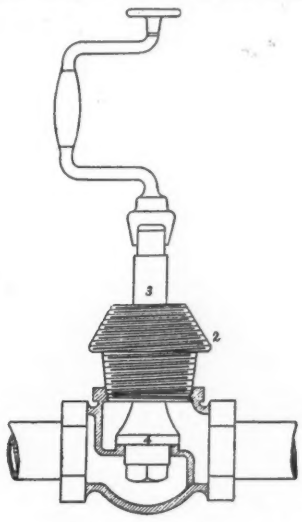


Fig 2.

before they are used, and then put back again without screwing them down so hard as before.

Fig. 2 represents a good plan for repairing the seat of a Jenkins Brothers valve. After the bonnet is removed, the

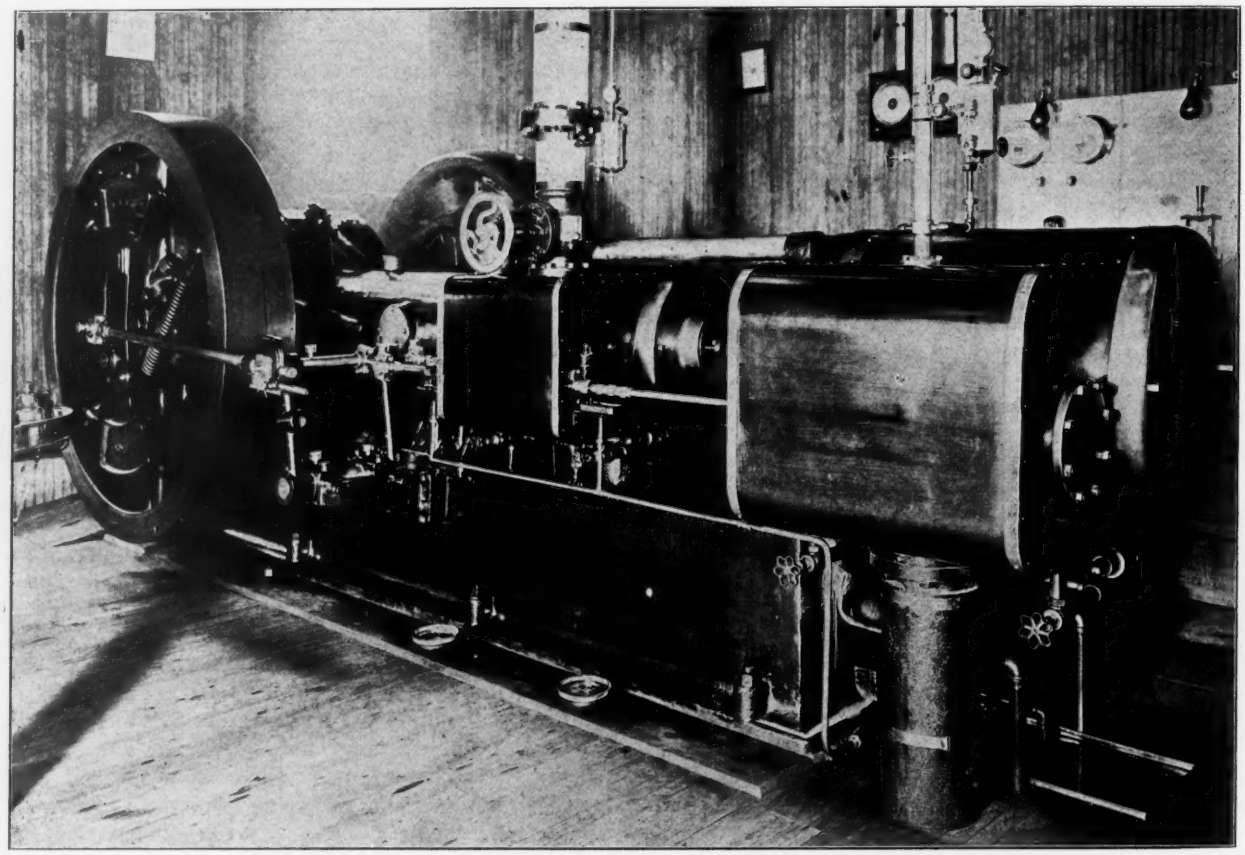
bushing 2 is screwed in to form a guide for the stem 3, on the lower end of which is a circular file 4. When this is turned by means of the brace, it files the seat until all irregularities are removed, making it as good as new.

This explanation should make plain the difference between putting in a new disc and repairing a valve seat. A set of bushings and valve files to repair Jenkins Brothers valve seats from ¼-inch to 2 inches in diameter, can be purchased for $6.00, therefore no steam user can afford to use valves with imperfect seats or worn out discs.

Power Plant of the Smith, Kline and French Co., Philadelphia

The laboratories of the Smith, Kline and French Company occupy an extensive area in the northeast section of Philadelphia. In these laboratories are manufactured chemicals of all kinds for the drug trade, extracts, compressed tablets, Eskay's Food, and also McNelley's American Boiler Compound, which latter demands a large section for its manufacture alone.

The principal machinery used in the manufacture of the articles mentioned above are grinders, sifters, blowers, stirring machines, and the like. All the machines are belt driven from motors. The smaller machines are driven from shafting which is driven by a large motor, while the larger machines are each belted to their individual motor.



250 H. P. Phoenix Engine in the Engine Room of the Smith, Kline and French Co., Philadelphia

Steam for the plant is generated in three boilers of the return tubular type, two of which are 16 feet by 72 inches and one is 16 feet by 66 inches, manufactured by Sotter Bros., of Pottstown, Pa. The boilers are equipped with the regular fittings and use anthracite buckwheat coal for fuel.

The boilers are fed with one simplex Cooper pump and one duplex, 5¼ x 3½ x 5, Worthington pump. The feed water is obtained from the city mains and is pumped through a Stone feed-water heater. Arrangement is made in the boiler feed pipe for introducing boiler compound, a small quantity of which is fed into the boiler about twice each week, and although the boilers have been in continuous service for a long period, their interiors are as clean as a whistle. All the drips from the steam pipes are carried to a closed tank, from which it is pumped to the boilers by a 4½ x 2¾ x 4 Blake pump. All the city water is first filtered through four Robertson filters before being used.

The engine room contains a 250 horse power Phoenix engine directly connected to a multipolar General Electric dynamo. The engine is of the tandem compound type with cylinders 15 and 23 inches in diameter and 16-inch stroke. The generator is capable of giving out a full load current of 1280 amperes at 120 volts when running at a speed of 230 revolutions per minute. The engine is equipped with Powell

sight-feed lubricators and Lunkenheimer's grease cups, in which Albany grease is used. An Anderson trap takes care of the condensation from the separator and a Watson and McDaniel trap takes care of the accumulated moisture in the exhaust pipes.

The generator supplies the outside circuits through a grey marble switchboard, consisting of two panels, on which are a Western voltmeter and ammeter, one main dynamo switch and circuit breaker and six two-pole single-throw switches. Besides a lighting load of about 800 incandescent lamps, there is a large motor load consisting of one 75 horse power Sprague motor which runs the main shafting, one 50 horse power Sprague motor, which runs the mills where the boiler compound is made, one 30 horse power and one 15 horse power motor are used in the Eskay's Food department, one 10 horse power Eddy motor runs the elevator, one 18 horse power motor is used in the candy department, one 10 horse power General Electric motor is used in machine shop, one 5 horse power General Electric motor is used for the stirring machines, one 3 horse power Crocker-Wheeler motor is used in the printing press room, one 7½ horse power General Electric motor is used for the tablet presses and several small motors are used for ventilating fans.

Perhaps one of the most interesting things about the plant is the fire system. In this connection, there are six stations on different floors from which an alarm can be sprung and to which the fire corps run when an alarm is sounded. At each station there is a fire line with a long hose ready for instant operation. When an alarm is struck, which is done by merely turning a switch, it sets in operation throughout the building a number of gongs and lights an incandescent lamp of a certain color on each floor, which indicates from which station the alarm is struck.

The employees on the fire brigade, with extinguishers, axes, etc., rush to that station, while other employees perform various other duties, the fire pump being started by the fireman. On account of the large amount of inflammable material stored in the building, some system of this kind is rendered necessary in connection with the regular automatic sprinkler system.

Besides the city water, a driven well 280 feet deep supplies artesian well water, which is used regularly for some of the manufacturing processes, but which can be used in an emergency for boiler feed water and fire purposes. A Clayton deep well pump is used for pumping the water from the well to a tank situated on the roof.

TESTING A STEAM TURBINE

Methods and Precautions Used in Making a Feed-Water Test

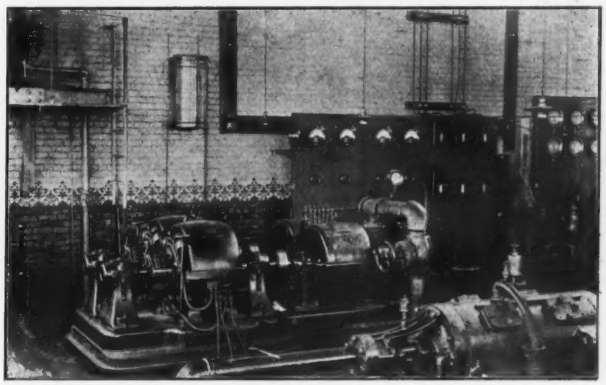
There has been quite a discussion of late in regard to the probable deterioration of steam turbines, after having been in actual service a number of years, and the effect of same on the steam economy of the machine. On account of the comparatively recent introduction of the steam turbine into this country, the information in this line has been more or less meagre, although this is not the case in Europe. The results obtained and methods used by Professors Edward F. Miller and R. R. Lawrence, of the Massachusetts Institute of Technology, in tests made recently on a 150 horse power steam turbine dynamo set, which has been in service at the New England Structural Co. for the past two years, are given below.

Shortly before the test was made, the turbine was taken apart and thoroughly examined as regards wear, etc., photographs being taken of the turbine wheel, buckets and pinion, which are reproduced herewith, and by examining same it will be noted that the wear on all these parts is practically *nil.* This machine is one of a pair which were built by the De Laval Steam Turbine Co. at their Trenton, N. J., shops, in the spring of 1903, both machines having been constantly in service at the New England Structural Co., East Everett, Mass., for furnishing power and light for their entire plant. A photograph of the installation is also reproduced herewith.

These machines were ordered under the following steam guarantees: With 150 pounds steam pressure at governor valve and 26" vacuum at the turbine, 18.7 pounds of steam per brake horse power per hour at full load, and 19.7 pounds at half-load. By comparing these figures with those just obtained by Professors Miller and Lawrence, it will be noted that the turbines are still well within their original guarantees, thus proving that the deterioration, if any, in this turbine, has apparently not affected the steam consumption.

The test took place on June 11th last, starting at 9.00 A. M. and finishing at 6.00 P. M., after which the electrical heat losses were obtained in order to determine the absolute brake horse power.

The steam supplied to the turbine under test came from one boiler. Steam for the auxiliaries and for the feed pump supplying this boiler, came from a second boiler. All condensation in the steam main leading to the turbine was returned to the boiler by means of a steam loop. The steam used was determined by weighing the feed water put into the boiler. The level in the boiler was kept nearly constant during the test, and was made the same at the end as at the beginning.

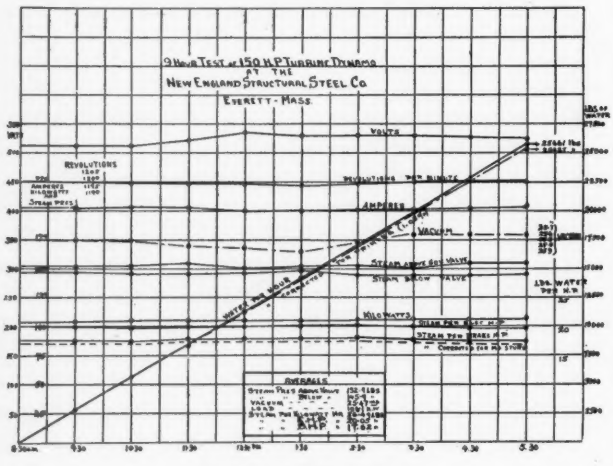


Interior of the New England Structural Steel Co.'s Plant at East Everett, Mass., showing Turbine Unit which was tested

The blow-off pipe and the auxiliary feed pipe were disconnected and blanked. All the piping, both steam and feed, was kept tight, and there were no leakages to make allowance for; all the water put into the boiler being used in the turbine and in the calorimeter.

The feed water was weighed in a barrel on a pair of scales sensitive to less than one-quarter of a pound under maximum load. The water weighed was run into a small barrel beneath the scales. The feed pump pumped from this barrel to the boiler. It is probable that the water weight is correct to less than 25 pounds in the total.

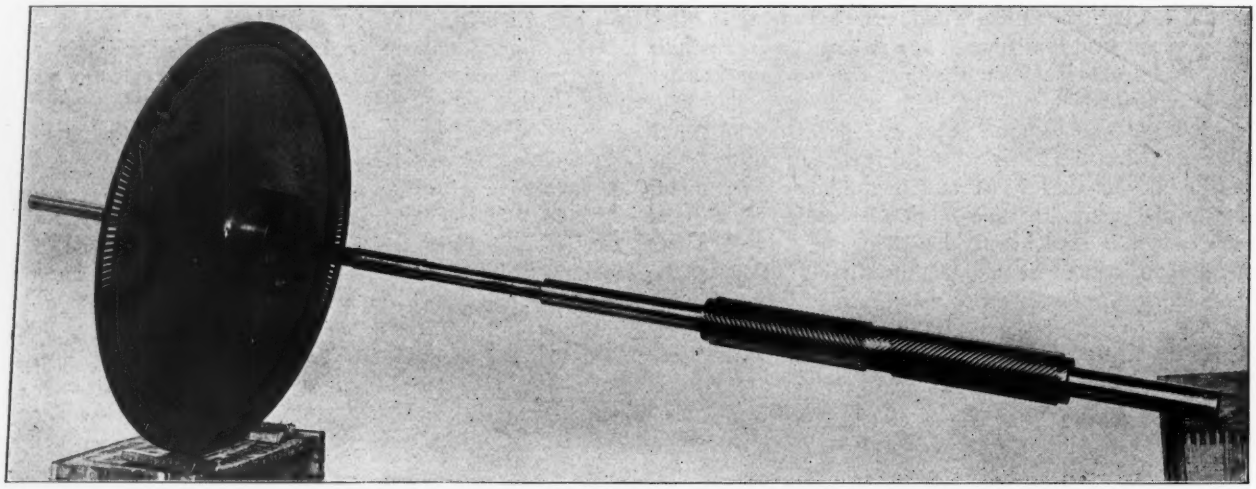
The quality of the steam was figured from readings taken on a throttling calorimeter placed near the throttle of the turbine. The time the calorimeter was in use was noted and the amount of steam used by it was calculated by Napier's formula. The orifice used to do the throttling was ¼" in diameter.



Results of 9 Hour Test

Pressures were taken at the throttle and in the case supplying the nozzles. This latter pressure is beyond the governor, and fluctuates with any change of load. Temperatures of the steam at these two places were taken also. It was thought that the throttling by the governor might dry out any slight amount of moisture in the steam, and that the steam entering the nozzles might be slightly superheated. During this test the throttling was slight; and there was but little change in the quality of the steam in passing through the governor valve.

The vacuum was measured by a U-tube filled with mercury. The poorer vacuum obtained near the middle of the test was due to low water in the river. The electrical output was taken up in a water cooled resistance. The necessary electrical instruments were inserted for the measurement of the power.



DeLaval Bucket Wheel, Shaft and Pinion after being in use Two Years

The load was very steady throughout the test.

Previous to starting on the test, the turbine had been running 45 minutes. Turbine ran with but little noise.

Duration of test	9	hours.
Boiler pressure gauge	152.9	pounds.
Boiler pressure below governor valve	145.9	"
Number of nozzles in use	6	
Quality of steam	1.05	pr. ct. priming.
Barometer	29.90	inches.
Vacuum	25.47	"
Average volts, dynamo No. 1	262.7	
Average volts, dynamo No. 2	262.1	
Total amperes	202.0	
Average total kilowatt output	106.1	
Average total electrical horse power output	142.2	
Average total brake horse power input	160.4	
Average number of revolutions per minute	1,200.0	
Total steam used for nine hours	25,661	pounds.
Average steam per hour	2,851.0	"
Average steam per hour, corrected for moisture	2,826.0	"
Steam per kilowatt hour	26.49	"
Steam per electrical horse power hour	20.05	"
Steam per brake horse power hour	17.77	"
Steam per brake horse power hour, corrected for moisture	17.62	"

The electrical instruments were all calibrated before and after the test by Prof. F. A. Laws, also of the Massachusetts Institute of Technology.

Electric Drive for Cotton Mills.

By A. S. Atkinson.

The changes and improvements effected in the adoption of electrical power for driving machinery in cotton mills are of far-reaching importance, and both in the South and in New England electricity is coming in for more attention than ever before. With electric motors aggregating some 140,000 horse power in operation today in the cotton mills, it is quite apparent that as a factor of a permanent character, electricity must be considered from every point of view. As an engineering problem requiring particular study in each individual case, the electric drive of a mill must be considered from the point of view of the cost of power, its source, and its practical application for saving time and labor through increased output.

In a great many cases the electric drive cannot compete with steam in cost, but if it increases the output and saves in power when the different machines are not in use, there is a gain which may compensate for any difference in the production of horse power. As a rule, in a factory devoted to the printing of cotton fabrics, the machinery is usually in operation all the time, and the consumption of power is pretty uniform throughout the day. There is consequently less gain by the electric drive in such a factory than in mills where from ten to twenty per cent. of the machines are thrown out of operation for one reason or another most of the time.

One-half to two-thirds of the power used in a cotton factory is wasted by the friction of shafting with bearings, and by dispensing with shafting and belting there would be a great economy obtained. The electric drive by distributing the power by wires to individual motors proves of great economical importance in this particular field. A factory that is wired for electric driving is more independent in its operation than another. Where it is desirable to suspend operations in one department until another catches up, there is no waste of power. Only such electrical power actually used to drive machinery is charged against operations.

The ideal factory is one in which the maximum of efficiency can be obtained from each unit working, and when not in operation loss or waste is entirely eliminated. Where machines are electrically driven this end is obtained. The question of economy of space is also important. By doing away with belts, pulleys and overhead machinery, we secure a compactness of power and efficiency that reduces the amount of space reserved for machinery from ten to twenty per cent.

Over 50 cotton factories in the country purchase electric current direct from power producers either for auxiliary purposes or for operating all of their machinery. The relative cost of electric current varies considerably in different parts of the country, and the question of economy of operation cannot be definitely settled except where prices can be compared. In parts of New England, where current is purchased from outside sources, the rate has averaged as low as two cents per electric horse power hour, or 25 cents per hour per brake horse power, or about $75 per year. In a number of these cotton mills, electricity is used for lighting purposes and for auxiliary neeeds in the summertime when the water power is low. Instead of closing down all of the factory in the summer months, certain departments are operated by electric power. In good seasons it has been found that such operation is profitable when outside current can be obtained at above prices.

The hydraulic development of streams for electrical operation of cotton mills in the South has assumed considerable importance in the past few years, and the equipment of the mills with electrical machinery has completely revolutionized past conditions. At Columbia, South Carolina, the equipment of the mills with electrical machinery has proved satisfactory and furnished some excellent data to show the advantages of this power over steam or water power. More recently preparations have been satisfactorily advanced in installing a number of cotton mills with electric power at Fayetteville, North Carolina. By constructing a dam 1500 feet long to back up the water for some ten or twelve miles, the Cape Fear Electric Power Company will be able to furnish a number of cotton mills now in the course of construction with cheap electric power for their operation.

In New England, the cotton mills scattered along the coast are in many instances unsatisfactorily located so far as hydraulic power is concerned. The streams have low heads, and in the summer months they run dry, so that auxiliary steam power must frequently be used to operate the mills. But the transmission of electric power over long distances has in recent years solved the problem for many cotton mills of New England. The water systems of these States can be connected in series for the furnishing of electric power. By harnessing the streams in the interior where they have an altitude of several hundred feet above the sea-level, it is possible to make use of streams that today are considered of no commercial value. In California, Mill Creek, a stream not much larger than many abandoned water-courses in New England, helps to furnish electric power transmitted to Los Angeles, over eighty miles away. The power house at the foot of the mountains utilizes every gallon of water that pours from Mill Creek down the flume, and by connecting several such power houses in a series, over 10,000 horse power is transmitted to the coast for industrial uses. Similarly the inland streams of New England could be harnessed and connected in series for the transmission of cheap electrical power to the cotton mills along the seacoast.

At Blackstone, Massachusetts, new electrical transmission of power has been recently attempted by the Blackstone Manufacturing Company for its cotton mills, and it serves as an illustration of what may become the rule instead of the exception within a short time in many parts of New England. The available horse power at the point on the Blackstone river where the power plant is located is 1500 in winter, and 600 in summer, with an average throughout the year of one thousand horse power. The head of the stream at the power house is 32 feet. Owing to the difference in the supply of water power in summer and winter, both steam and hydraulic power will be used for generating the electricity. A compound engine is direct-connected to a generator of 100 horse power, and this will deliver to the mill 440 volts of alternating current. But the main dependence of the mill are the four thirty-six inch water-wheels direct-connected to an 840 kilowatt generator, which makes 200 revolutions per minute, and develops 1120 horse power. In addition to these four large water-wheels there is a twenty-inch turbine of 100 horse power which is used for lighting the mill, and in emergencies it could be used for general mill purposes. By thus utilizing the power of the stream for generating electricity it is expected that a saving of twenty per cent. or more will be effected in cost of power development, and the output of the mill increased from ten to twenty per cent.

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A Step in the Right Direction.

In another column of this issue, there will be found the report of the committee of the National Electric Light Association appointed to investigate the steam turbine. While very meagre in some of its details, principally on account of the lack of data available, it is refreshing because it is the first report of its kind that we have seen which takes up some of the troubles experienced in the operation of the steam turbine unit.

It is quite natural, when a new machine or piece of apparatus is placed upon the market, to doubt its efficiency and durability of operation, but there never was perhaps a piece of apparatus invented in the steam engineering field that enjoyed the uninterrupted respect which the steam turbine has attained. For a long time everything which was said about it was believed to be true and even its competitors dared not say anything about what was considered to be a model piece of apparatus. Anything that was said detrimental to it was considered almost as treason to a just cause.

After, however, the first haze of admiration disappeared, it was found that the steam turbine did not differ from any other piece of mechanism. It undoubtedly has its advantages but it also undoubtedly has its disadvantages. Just what these disadvantages were was not easily ascertained because the steam turbine is a self-contained piece of mechanism and the casual observer had no way of discovering what was taking place within its iron-clad walls. Even the operating engineer could not tell what was going on and had to wait the test of time.

Now that the steam turbine has emerged from its infant state and has begun to grow rapidly, it is only natural that an impartial discussion of the subject should take place, so that the prospective user of this type of apparatus should know what to expect from this type of prime mover.

The steam turbine question has been very similar to what took place in earlier days of electricity. In those days, the manufacturer of electrical apparatus threw as much mystery around the dynamo and motor as possible and fortunate was the man who could get any reliable information in regard to their construction. When an armature or field burnt out, the part in question was taken away and sent back repaired with hardly a word of explanation, all of which did the industry much harm. The intelligent discussion of what had happened and the interchange of ideas soon prevented many of the above occurrences and the growth of electricity may be said to truly date from that time.

The discussion of the turbine question in all its aspects is just as badly needed, so that the report of the committee of the National Electric Light Association meeting may be said to be a step in the right direction.

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At What Steam Pressure Should a Plant be Run?

One question which is frequently asked us and one which is not always easy to answer is: "What is the proper steam pressure to run a given plant?" In a majority of plants, the maximum pressure is fixed by the construction of the boiler or by the results of a boiler inspection, so that in that case only pressures lower than this maximum need be considered.

One of these cases recently brought to our attention is where a 200 horse power engine is only doing about 60 horse power of work and the engineer complains that with the setting of his valves, the indicator diagram shows the expansion line, running below the back pressure line, forming a negative loop.

The proper thing to do in this case is to lower the admission pressure until the expansion line comes at least to the level of the back pressure line at release. This can be done by either lowering the boiler pressure or, when there are a numbr of auxiliaries demanding the higher pressure, by using an expansion valve in the main steam pipe leading to the engine. This valve can then be so adjusted as to give whatever admission pressure is desired, usually one which will allow cut-off to take place about quarter stroke. Whether this or any other pressure is the most economical can only be determined exactly by experiment.

It is in the construction and design of a new plant, however, that this question becomes of the most importance. For instance, another engineer writes: "What kind of boiler should I buy and at what pressure should I run my cross compound condensing engine?"

Taking modern practice for example, it is found that boiler pressures rarely exceed 150 pounds for almost all kinds of stationary service and it may be interesting in this connection to know just why this is. Compound engines are made for marine work which run at much higher pressures and boilers of the water tube type can easily be built to safely carry higher pressures. In marine work, it is necessary to get as much power from an engine for a given size as possible and since

twice the power can be obtained from a given engine with the same ratio of expansion by using twice the initial pressure, higher pressures are used.

This does not mean that the engine will be more economical, because, to get any increase in steam efficiency with the use of higher pressures, a greater range of expansion must be used. To get twice the amount of work out of a given weight of steam, the number of expansions must be doubled, but if the same volume of steam is used at double the pressure, it means that approximately twice the weight of steam must be used and no greater economy. The difficulties of handling the higher pressures, especially in the pipe lines, are also a factor for consideration, so that whatever small advantage might accrue from the higher pressures would be offset by the decrease in safety.

The efficiency of an engine depends upon the difference in temperature between the initial pressure of the entering steam and the final temperature of the exhaust steam, and since the temperature of steam does not increase very rapidly in proportion to the pressure above 150 pounds, it is usual to keep the pressure of the steam plant below that limit.

Canadian License Law Turned Down.

The difficulty of securing proper license law legislation is apparently just as great in Canada as it has been in this country. This is shown by the fact that a most meritorious bill has recently been rejected by a committee of the Ontario Legislature appointed to consider it.

The bill was entitled: "An Act to Regulate Stationary Engineers" and it passed first reading before the Ontario Legislature. It provided that every engineer operating stationary or hoisting steam plants having a boiler of 25 horse power or over, shall hold a duly certified certificate granted by a board of examiners to be organized under the provisions of the Act; the said board to consist of at least three qualified persons appointed by the Government on the recommendation of the Minister of Agriculture, one member to represent the stationary engineers, one the boiler insurance companies, and one or more to represent the factories inspectors. The board was to issue without further examination certificates to all engineers who could produce satisfactory evidence of having served in such capacity for at least four years within the province, and who should also produce satisfactory evidence of good character. All certificates issued by the board should at all times be exposed to view in a conspicuous place in the engine or boiler-room; and the omission so to expose it was to be considered prima facie evidence of the lack of qualification required under the Act. Any fees for examination decided upon by the board not to exceed two dollars, and the fee for certificates thereafter not to exceed one dollar. Every boiler inspector appointed under the Act to make a report to the board of examiners of every boiler inspection made within ten days of making same, and neglect to do so should be sufficient reason for cancelling his appointment, and every company authorized to insure boilers to send annually a full list of boilers insured. Owners of plants using steam boilers of 25 horse power or over who permitted a person to take charge of said boiler who could not show the required certificate, would be liable to a fine; and every engineer who assumed control of such a boiler, not having the required certificate, should also be liable to a fine.

In the discussion before the committee it was advocated by the Stationary Engineers' Association on the ground that it was intended to protect human life; and it was combatted by representatives of the farmers, and also by a delegation from the Manufacturers' Association led by Mr. Stewart, the secretary, who urged that there was no necessitw or general demand for such legislation.

In this connection, we are glad to see that the *Canadian Manufacturer,* a paper devoted to the manufacturing interests of the Dominion of Canada, has come out in favor of this bill and it is to be regretted that manufacturers themselves do not take the same stand. In their comment upon the bill, the *Manufacturer* says: "The requirements of the bill were, without doubt, as here shown, exceedingly simple and reasonable, and the opposition to it indicated a disregard for human life, growing out of extreme selfishness. Hundreds of steamers, yachts, tugs and pleasure boats, plying the waters of the province, propelled by steam, are forbid to leave their docks until every requirement of a stringent Dominion law has been complied with—a law passed expressly to protect human life, but unfortunately that law is not applicable to the use of steam on land; and whatever law of that character may be passed must be done by the provincial legislature. Efforts to effect such laws such as that here alluded to are no new things, for Stationary Engineers' Association and others, who appreciate the necessity for them, have, time and again, for many years past, gone to the government, showing the necessity for them, only to be thrown down every time. The constant occurrence of boiler explosions in industrial and other establishments, and on farms also, with fearful loss of human life, causes but brief comment and is soon forgotten, except by widows and orphans."

When will the legislative bodies of this country, as well as of Canada, wake up to the fact that it is just as important to have competent and capable engineers in charge of steam plants on land as it is on the water?

Testing of Boiler Plates.

The Federal Government demands that every plate used in a boiler over which it has jurisdiction, shall be stamped with the name of the maker and with the tensile strength determined by a test in a proper testing machine. Such tests are usually made upon a piece cut from the end of the plate. Iron plates with a strength of 45,000 pounds per square inch are to show a 15 per cent. reduction in area and steel must show a 25 per cent. strength in a length of 8 inches. Bending tests are also required; for thicknesses of three-quarters of an inch and under, the plate should bend double, both hot or cold, under a heavy hammer without showing cracks at the bend, and thicker plates should bend with a radius equal to their own thickness at the inside without showing distress.

On account of the velocity of the moving steam in a steam pipe, it is impossible for the water of condensation to move in any direction except along with the steam, so that the steam pipe should be graded from the boiler towards the engine and provision made at the engine end to catch or dispose of this water.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

Steam Piping Alterations for Economy.

EDITOR THE PRACTICAL ENGINEER:

Some time ago I became convinced that I was using too much coal for the work the engines were doing and also using more cylinder oil than I thought really necessary; and too much cylinder oil in a surface condensing plant is a serious matter, providing the oil finds its way to the boilers. In the plant in mention there are two duplex triple compound direct-pressure pumping engines, two air-pumps, two duplex boiler feed pumps, and two Clayton single-stage air compressors. On the discharge line from each large pumping engine is connected a steel tank 8′ in diameter and 16′ high.

These tanks are charged with compressed air to the pressure on the main line, the air in the tank acting as a cushion to retard the water hammer on the line, caused by quick opening and closing of valves along the line and by the motion of the pump plungers when operating at high speed. In order to keep these tanks charged full of air, the compressors have to be run but a short time once or twice a week. The main steam pipe to the large pumping engines is fitted with a 6″ cross, and two square bends lead from the sides of the cross to each pump, while one end of the cross is connected to the steam pipe from the boilers. From the other end of the cross the piping is reduced to 3″ and is carried straight out in line with the main steam pipe for 28 feet to where connections are made and the piping leads down to the air-compressor steam ends, with a suitable 2″ globe valve at each compressor as a throttle, over which a ¼-inch drip connection was put.

It had been necessary to keep these two drain valves open at all times, owing to condensation in this 50 feet of piping, and with these drains open, there must be some waste of energy, so I concluded to make some slight changes and remedy it if possible. Four of the cylinders of each pump are steam-jacketed, and the steam to their jackets is taken from just over the main throttle valve, through a ¾-inch pipe. Without interfering with this arrangement in any way other than to put a ¾-inch cross in place of a tee where the steam line is connected to the two intermediate cylinders and putting a globe valve near the cross so that if my alterations proved a failure, I could easily resort to the old method, I took out the ¼-inch drain valves and after closing the stop valve (at the cross on the main steam line leading to the air compressors), I put in the place of the ¼-inch valves, ¾-inch valves and lead the piping over to connect with the valve at the cross connection between the large pumps' cylinders.

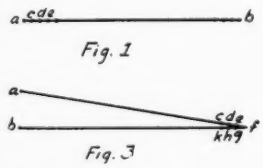
With this arrangement all connected up I tried the pump for two weeks and there is a noticeable saving in fuel and a wonderful difference in the amount of cylinder oil used. The steam jackets are just as hot as before, and there are no signs of clicking and water in the cylinders as before. Now I want to get rid of the duplex boiler feed pumps and when I do, it will make another saving, for they are about the most expensive adjunct to the steam plant, to my way of thinking, and they give the steam plant's efficiency the rheumatism.

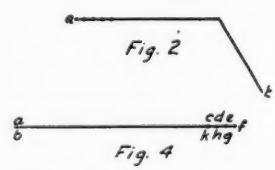
MICRO.

How it was Proved.

EDITOR THE PRACTICAL ENGINEER:

It all began at one of the meetings of the Engineers' Club to which we all belonged. Someone, in a spirit of fun, asked whether the piston of an engine really stopped at the end of the stroke. Several of the older members said "chestnuts!" and most of us laughed. Then Hank Wilson spoke up. "Of course, it doesn't," he said. We laughed again. "And I can prove it," he declared, when the laughter subsided. Now, he is one of those fellows who are fairly bright and who like to show just how far they can eclipse any ordinary star in the solar system, and, of course, most of us actually wanted to see his self-confidence punctured. "It's up to you, I guess," drawled Benny Wallace. Hank was only too anxious to explain his views. In a moment he had sketched four figures on the blackboard, like those shown here. "For the sake of clearness in my explanation," he began, "we will suppose that the piston, piston-rod and crosshead are concentrated in one point, since they move together. You all know that motion is simply a change of position from one point to any other point. For





example, take Fig. 1. Suppose our piston, or as we shall call it, our point, to move from *a* to *b* along the line *ab*. Every line is made up of an infinite number of points. Hence, as our point moves from *a* to *b*, it passes through all the points in succession, as from *a* to *c*, *c* to *d*, *d* to *e*, and so on. If the line were curved, instead of straight, the action would be the same. If it made a sharp turn, as in Fig. 2, our point would still have continuous motion in passing from *a* to *b*. The fact I wish to make clear and upon which my proof rests, is that motion consists simply of change of position from one point to a consecutive point, and that so long as a body is undergoing this change of position, it is in motion and not at rest. Bearing this in mind, turn to Fig. 3. Here the line *ab* is still further bent, so as to form an acute angle. Suppose a point to move from *a* to *b*. It would occupy successive positions until it reached *e*. From *e* it would pass to *f*, then to *g*, *h*, *k* and so on to *b*. There would be no stopping, since it has fulfilled the condition of changing position continuously, from point to point. Now, finally, suppose the lines *af* and *bf* of Fig. 3 to be brought together, as in Fig. 4, the points *a*, *c*, *d* and *e* coinciding with the points *b*, *k*, *h* and *g*, respectively. We now have the two lines practically in one, the upper letters representing the points in the line *af* and the lower letters the points in the line *bf*. If our point now moves from *a* to *b* by

way of the point *f*, it must pass successively through the points *c*, *d*, *e*, *f*, *g*, *h* and *k*, and in so doing, according to my definition of motion, there can be no pause or stop. That is why I say that the piston does not stop at the end of the stroke." He smiled upon us with an air of superior wisdom, and challenged us to give proof to the contrary. We were silent. There wasn't a mother's son of us that believed his conclusions. We had either seen or read of the effects produced when a piston refused to stop at the end of the stroke, and went meandering on through the cylinder head, a partition or two, a brick wall, and several yards of air. But for all that, we were mum. Hank's explanation was so weighty in its logic that we felt the atmosphere growing oppressive. So we adjourned without even a motion to that effect. But once outside, we got going again. "I don't think he believes it himself," ventured Jake Olafson, who works down at the steel mill, "and I've been thinking that I could bring him to see it in a different light, without much delay." Of course, we wanted to know his plan, and he unfolded it to four of us. The following week contained a holiday, and Jake was to invite a number of us, including Hank, down to the mills to look over some improved machinery that had just been put in. After that, the matter would be in our hands. Well, we gathered at the mill office about one o'clock, and with Jake guiding, went over the plant, much interested in the machinery and the work being done. On our way back, we paused a moment before a large steam hammer, while Jake explained that it was merely a reciprocating steam engine, without connecting rod or crank attachment, and that the force of the blow could be varied to a nicety by the operator. He offered to show us, and stepping forward, laid his hand on the lever. That was the cue for the four of us who were in the secret. Like a flash we grabbed Hank and laid him, face upward, across the anvil. Then Jake moved the lever, and the hammer came down. For a moment we held our breath, for it seemed that the hammer would strike him, although we knew that the anvil block had been removed to prevent any serious danger. But just as it was about to touch his coat, it reversed, and hung again motionless in midair. I hope I may never again hear such a yell as Hank let out when he saw the hammer descending. When we set him on his feet again, he was trembling all over. His face was as pale as a sheet, and the sweat stood out on his forehead. "Well, Hank," said Jake, laughing, "does a piston stop at the end of its stroke?" And Hank admitted that it did.

X. N. TRICK.

What was the Object in Drilling These Holes?

EDITOR THE PRACTICAL ENGINEER:

As I am a reader of your valuable paper, I would like to ask you a question. I am an engineer at a plant where they manufacture alcohol out of sawdust. We have one high-pressure circulating pump, 5¼ x 3½ x 5, which is connected to a 15-ton ice tank and which circulates the cold water through the acid tanks.

When I took charge of this plant, this pump gave me quite a lot of trouble; I would have to watch it very closely to see that it would not stop. When it did stop, it would blow live steam right through into the exhaust. I examined the pump in the water end and found everything all right there and then I took off the steam chest cover to examine the slide valves on the steam end. The trouble was there.

The valves had four $^{3}/_{16}$-inch holes drilled through them. I asked the night engineer who drilled the holes, and he told me the pump was knocking very badly and the man that was in charge before I came drilled the holes and set the valves and they never had any trouble with the pump.

Now, what I want to find out is: "What was his object in drilling the holes?" Kindly explain, if you can do so, or maybe some other reader of "The Practical Engineer" can and will oblige a reader of your valuable paper.

J. M. C.

Answer to C. A. T.'s Question "Can This be Done."

EDITOR THE PRACTICAL ENGINEER:

Your correspondent C. A. T., in the June number, has brought up a very interesting problem in the use of an air compressor and a gasoline engine working together, in such a situation that each may be got to help the other. The proposal made is to lead the exhaust gases from the engine cylinder, by means of a pipe, through the air storage tank, in order to reheat the air. But there seems to be a still better arrangement possible.

In a gasoline engine there is a large amount of heat taken away by the water circulating in the jackets; in a test which I have beside me of a 5 brake horse power Priestman oil engine, the results are as follows:

Heat given in useful work	12.67 per cent.
Heat given to jacket water	53.39 per cent.
Heat given to exhaust, etc.	33.96 per cent.
	100 per cent.

It will be noticed that the largest loss is in the jackets, and it ought to be possible, by making the cold air take the place of the water, to get a saving here; unfortunately, special jackets would be necessary because of this fact, which your correspondent must bear in mind, namely: that air is a very poor conductor of heat, and in order that it may take heat from or give heat to an iron wall, it must have a scrubbing action given to it by the use of baffle plates or coils of pipe. Overcome this difficutly of making the air absorb heat readily, and there is the possibility of a great increase in economy; unfortunately, I have had no experience in this work, so cannot advise further.

The advantages of reheating are obvious; it prevents the very great cooling of air working expansively, which cooling usually makes it necessary to provide an arrangement by which hot water or steam is injected into the cylinder, to prevent trouble owing to the freezing of moisture in the air; hot air occupies a larger volume than cold air at the same pressure, so that less of it is used per stroke, the relation being

$$V = v\left(1 + \frac{t}{273}\right)$$

where "t" is in degrees centigrade, which shows that the efficiency could be doubled could we only heat the air to 270° C. The exhaust gases from a gas engine may reach a temperature of 800° C.; on this account the question of substituting air for water to cool the cylinder would require careful consideration, and it seems to me that much useful information in the

heating of a volume of air, or what comes to the same thing, the cooling of a mass of hot iron, may be got by the study of the methods adopted for this purpose in automobile work.

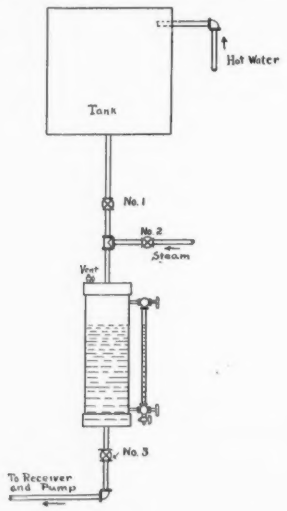
Cincinnati, Ohio. A. MILLAR GRAY.

Arrangement for Feeding Boiler Compound to Boilers.

EDITOR THE PRACTICAL ENGINEER:

Herewith find a sketch of a rig I made for feeding boiler compound into boilers. I took a piece of 4-inch pipe, 18 inches long and put caps on each end with openings for ½-inch pipe.

I put my compound in the tank overhead and let it run down to the lower one and when full, I close No. 1 valve and open No. 2 and regulate it with No. 3 valve. The compound goes to a receiver and the pump takes it and forces it into the boilers.



Arrangement for Feeding Boiler Compound to Boilers.

The receiver is under pressure, which is the reason for steam connection No. 2. I dissolve the compound in hot water in the upper tank and in this way the boilers can be given a dose at any time while running.

Danbury, Conn. J. M.

Horse Power of Air Compressors. Water in Gauge Glass.

EDITOR THE PRACTICAL ENGINEER:

I herewith enclose my solution of H. L.'s problem in the June issue, regarding the work done by his air compressors.

The work done per revolution when running 92 revolutions per minute was 3.5 horse power for No. 1 and 9.46 horse power for No. 2, when running 75 revolutions per minute. At the reduced velocity of the piston, when the No. 1 engine was averaging 74.5 revolutions, the work done per revolution would be for No. 1

$$92 : 3.5 :: 74.5 : x, \text{ or, } x = 2.83 \text{ horse power.}$$

Since No. 2 is running at 57.78 revolutions, the horse power given out at that speed would be

$$75 : 9.46 :: 57.78 : x, \text{ or, } x = 7.28 \text{ horse power.}$$

Then for No. 1 engine running at 74.5 revolutions per minute the horse power would be $74.5 \times 2.83 = 210.8$ horse power and for No. 2 engine, running at 57.78 revolutions per minute, the horse power would be $57.78 \times 7.28 = 420.6$ horse power.

No. 2 engine developed 420.6 horse power continuously for 11 hours, while No. 1 ran only 6.5 hours. 210 horse power developed continuously for 6.5 hours is equal to 124.5 horse power developed continuously for 11 hours, therefore $420.6 + 124.5 = 545.1$, average horse power for the day's run.

L. F. B., of Tewksbury, Mass., also wants to know if the water should be blown from the glass or allowed to remain, when the glass is left for the night. The answer is that it should be allowed to remain. I should say blow it out, because it seems to me that for a man to come into his boiler room in the morning and find no water in the glass is one of the best reminders that his gauge glass is shut in and that he must open the valves.

New Bedford, Mass. F. W. C.

J. M.'s Reply to G. R. K.'s Answer in Reference to Indicator Card.

EDITOR THE PRACTICAL ENGINEER:

In answer to G. R. K.'s answer, in the June number, to my question in the May number, I would say this: He advises more lead and he says that the undulations are in the compression line and not in the steam line. G. R. K.'s ideas as to the location of the steam and compression lines are new ones to me. I would also say that my engine has lead enough and I think that this card is as good as the average.

What I wanted to know was the cause of the irregularities at the top of the card. I would say that this card is from a four-valve automatic cut-off engine overloaded. I think the irregularities on the card are caused by the momentum of the moving parts of the indicator.

Danbury, Conn. J. M.

Corliss Valve Setting. Discussion Wanted.

EDITOR THE PRACTICAL ENGINEER:

In regard to my contention on setting the eccentric on a Corliss valve gear, or any valve gear, I would say that I am still unconvinced that I am wrong and maintain that I am correct.

All straight Geo. H. Corliss engines of later types have their connection of the hook rod to the wrist plate below the centre and the eccentric is behind the crank, but you have got to move your eccentric around on the shaft in the direction that the engine is to run, regardless of this fact.

If this is not correct, then it is pretty near time my engine started to run backwards, for my eccentrics are set that way and if I want to increase my lead, I move my eccentric ahead in the direction that the engine runs and my indicator card proves the correctness of my statement.

We have a Harris-Corliss also in the plant. On this engine, on the low-pressure cylinder, the connection of the exhaust hook rod to the exhaust wrist plate is below the centre and the pins which carry the rods connecting to the valve stem are above the centre, which gives compound movement; now how are you going to set the eccentric in this case? Just the same as I have stated and I can prove it.

The connection of the steam hook rod to the steam wrist plate on the same cylinder is above the centre and the pins carrying the rods that connect on the valve stem are below the centre; how will you set this eccentric?

There is an engineering book on the market today that states that the eccentric will have to be moved around on the

shaft in an opposite direction to that which the engine is to run if the connection is below the centre or if there is a rocker-arm to reverse the motion of the eccentric, but this statement is wrong and very misleading.

So far, I have heard only from the editor. What's the matter with the engineers? Brother Wakeman and a few others worked pretty hard with three foot pipe wrenches and 3/8" valves; let's hear from them on valve setting.

New Bedford, Mass. F. W. C.

Water Columns Should not be Renewed Every Eighteen Months.

EDITOR THE PRACTICAL ENGINEER:

I do not agree with C. H., on page 23 of the June issue, where he says that water columns should be renewed every eighteen months. I think that if a water column is blown out every day and the pipes arranged so that a rod can be run through them when the boiler is washed out, there will be no trouble with the column getting filled with scale. I think it would be an unnecessary expense to renew the column every eighteen months.

The water columns and fittings on my boilers have been in use for seven years and in all that time I had no trouble with scale in them. The only repair I had to make was the putting in of a new nipple which was worn out.

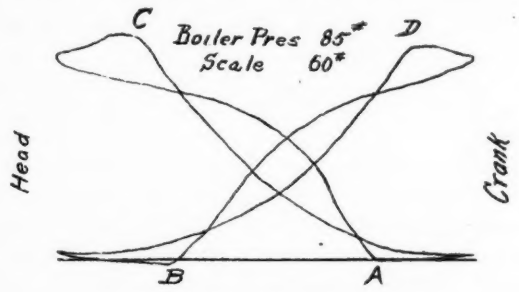
Milwaukee, Wis. H. J.

A Lesson in Valve Setting.

EDITOR THE PRACTICAL ENGINEER:

I enclose you two indicator cards, which you might like to publish, as the first is an exaggerated case of a trouble often met in actual practice, and the second shows the trouble corrected. These cards were taken from a new 10 x 12 automatic engine, the only symptom of trouble being that the engine would not run up to speed. Card No. 1 was taken and at once located the trouble, and after the valves were set, card No. 2 was taken with the engine running at about full load.

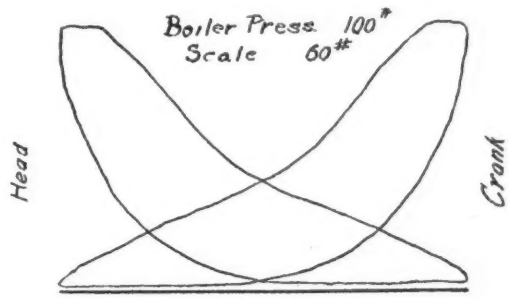
Perhaps your readers would like to know what caused this card? The whole trouble was that the eccentric was set back



Card No. 1.—As the Valves were found.

by an angle equal to what the angle of advance should have been. In the automatic governor of this engine, the eccentric is shifted in a slide at right angles to the crank. To reverse the engine, this slide is revolved through 180 degrees and then the eccentric is set around on the slide by an angle equal to twice the angular advance, the exact positions in each case being obtained by taper bolts. The owners, on setting up the engine, wished to reverse it and had moved the slide 180 degrees all right, and as the engine ran backward they never suspected that they had not finished the job.

Referring to card No. 1, A and B are the points of admission, D and C points of cut-off. It will be seen that the area of the two negative loops is almost equal to that of the positive part, so that it is no wonder that the engine did not run up to speed.



Card No. 2.—After the Valves were set properly.

Clearfield, Pa. W. A. S.

Stopped-up Steam Pipe Prevented Lubricator from Working.

EDITOR THE PRACTICAL ENGINEER:

A short time ago, I noticed that one of my lubricators, which is of the sight-feed type, would not work the way it should, as the drops would come out in jerks, and I thought probably that some of the small pipes in the lubricator were clogged up, so I cleaned them out good by blowing steam through them but when I filled the lubricator again I found the same trouble was there yet. I could not see what was the matter as I was sure everything was clean. I then closed the angle valve on the pipe which leads to the condensing chamber and disconnected the pipe from the chamber.

When I opened the angle valve again I found very little steam blowing through the pipe, so I saw at once where the trouble was. The pipe between the angle valve and main steam pipe was clogged up, which caused the drops to come out in jerks, as there was not pressure enough in the lubricator. The next morning, I cleaned out the pipe by running a rod through it and the lubricator worked all right.

Milwaukee, Wis. H. J.

Would It?

EDITOR THE PRACTICAL ENGINEER:

I would like to have some of your readers answer the following questions:

In our hat factory plant we run a 14 x 26 x 26 tandem compound condensing engine 150 revolutions, steam 110 pounds and average 23 inches vacuum. Engine is direct connected to a 200 kilowatt generator. In one of the shops we have 60 tubs of various sizes, which hold from 30 to 60 gallons of water each, and which are kept boiling constantly by steam being blown through copper coil direct from boilers.

Treatment of Fibrous and Metallic Packings.

EDITOR THE PRACTICAL ENGINEER:

In looking over the engines of modern build, it is very interesting to compare the old timers with the new ones, especially so in the use of packing for piston rods and valve stems of all kinds. Years ago, engineers considered the question of piston rod packing very lightly. Any old thing was used to pack with, such as flax, old rope, waste, etc. Then the packing was crowded into the stuffing-box and pounded down till it was possible to insert the gland and then it was a case of screw up till it groaned and creaked at an alarming rate. At this later date, the selection of piston rod packing and the proper application are deemed of sufficient importance to engage the attention of all careful engineers who use them and yet there are a number of rods in use that show that there is still room for improvement. The cost of restoring these rods to a satisfactory condition is a great deal more than the difference in the cost of good packings. Worn-out rods cannot be turned up and replaced as easily and cheaply as good packing can be obtained.

There is a disposition among some engineers to allow packing to remain in use as long as it seems to hold. Then, when they commence to leak, the gland is removed and a turn or two of new packing it put in on top of the old burned stuff. This is often done without considering the accumulation of scale or crust which sometimes forms very rapidly, especially if an improper or poor lubricant is used. Frequent examination should be made and care taken to prevent scoring them by this means. The old packing should be removed and new substituted whenever necessary. A perfect piston rod in perfect condition is always a good advertisement and a pride to an engineer.

The packing manufacturers of late years have made great progress towards producing perfect packing to fit any and all conditions. Metal packings are slowly but surely superseding the old fibrous kinds. Some of these packings are successful to a certain extent but are subject to more or less leakage, owing to expansion and contraction. Metal packings need more care and attention than the old kinds of soft packing and will not stand so much abuse. I know of two engineers who tried metal packing. One used it for the period of about three weeks, coming out of the trial with a nicely scored rod. The other engineer ran a packing of the same kind and size for about 5 years and at the end of that time the wear was about one sixty-fourth of an inch and was taken out on account of repairs to the piston. This packing was of the sleeve variety and consisted of three sections with keys that nicely fitted into keyways that were milled into the edge of the sections, thus preventing steam from blowing through the joints. This packing was made of gun-metal and was so constructed as to be adjusted to the rod without taking the crosshead off the piston rod. After the repairs had been made, the same packing was put back on the rod after being filed off on the edges and the keys shortened up to allow the sections to go closer together. Metal packing does not need so much strain on the gland as soft packing, therefore this insures a good deal freer condition of running. In fact, the writer has seen packing that had the gland screwed up with the fingers and a locknut substituted to keep the regular nut from working off. One thing a good many engineers lose sight of is the question of lubrication. They would not for a moment think of allowing the cylinder to run dry for the need of oil and yet when you stop and think, the packing on the rod is metal on metal just the same as the packing in the cylinder. Another thing about metal packings that engineers do not seem to realize is the fact that when starting up in the morning, owing to the expansion and contraction of the two different metals contained in the rod and the packing, there is very often some little drip around the rod for a short time. Some engineers get after this with a monkey-wrench right away, taking it up until it runs perfectly dry. This is where they ruin their packing, for when they screw it up tight at once, when the engine has run a short time, the metal expands and it is too tight and so becomes hot and ruins the packing and often scores the rod. If they would let it alone for half an hour it would nine times out of ten take up itself. If it does not then, it should be taken up very gradually. Some packings are made of cast-iron but these I do not recommend, as they are rather harsh on the rod and are liable to cut unless they are to be used for ammonia as, in this case, cast-iron or white brass are about the only metals that will stand the test. Good gun-metal packings are best for steam, as, if they should be taken up too tight and heat, the metal in the packing will usually give before the rod does and thus save scoring it. Of course, some engineers will score a rod with anything. A little graphite mixed with cylinder oil and applied to the rod with a swab or a brush occasionally is very beneficial and has a tendency to produce a smooth surface on the rod and the packing, too. Taking altogether, metal packings are a success and given as good care as the rest of the engine they are expected to and will work well and give good satisfaction.

GRATE BAR.

More About Boilers.

EDITOR THE PRACTICAL ENGINEER:

I had intended to write a paper on the care and management of boilers, but the "Editorial" in December's issue of "The Practical Engineer" was so nearly what I intended to write (in many places the wording being exactly the same), that it would seem out of place to do so now, but I shall take the liberty to advise everyone interested in such matters to read the above-mentioned editorial carefully and often. What I shall now write will be in reference to boiler explosions.

It is my belief that boilers rarely explode while working under what might be termed normal conditions. Take, for instance, the Brockton boiler, made by a reliable firm and regularly inspected. Structural weakness would have shown itself years ago; weakness through age would have shown signs of development at its last inspection; the crack reported in the seam would have shown signs of distress had it weakened the boiler enough to have caused the terrible explosion which took place, admitting that it was carrying the very moderate pressure allowed by the insurance people.

Some years ago, I was testing a steam gauge; the first trial showed a pressure far below the test gauge, and upon examination I found the small passage leading to the gauge almost closed with a reddish-brown sediment; after cleaning this out, it registered perfectly.

I will further state that the sediment had collected in such a place and in such a way, that it was not easy to detect. This

fact and numerous others in connection with safety valves have led me to conclude that both may go wrong at the same time, especially when a boiler has been out of use for some months, and shows normal working pressure, when, in fact, the pressure is excessive. This I am convinced was the cause of the Brockton disaster.

I fully agree with the statement in the May issue of "The Practical Engineer" that it is rather a late day to render a verdict against lap-seam boilers. It is true that butt-strap seams are better but became a necessity on account of the extremely high pressure carried in recent years; but the boiler in question was only allowed moderate pressure.

A short time ago I was shown a piece of ⅝" boiler plate in which there was a groove 18" long by ¾" wide. At one end it was just eaten through the plate and at the other end there was only a depression. I asked the boiler-maker how it was discovered. His reply was that a small leak was detected, so the warning was heeded and repairs made at once.

In the course of a conversation with an engineer of one of the largest railroad corporations on this Continent, he stated that his Company had locomotives in use built in the United States, Germany, and Scotland; that the American engines proved the best; that the German engines showed signs of weakness in a short time, and the Scotch engines in even less time, the tubes, seams and stay-bolts commencing to leak, due no doubt to structural weakness. The warning was heeded, the engines sent to the shop and were thoroughly repaired and strengthened.

My conclusion is that structural weakness, weakness occasioned by long use, undue accumulation of sediment, grooving, etc., always give timely warning to the careful and experienced, and that explosions rarely occur from the above causes, but are caused either by pressure far in excess of the normal or every-day working pressure, or by gross ignorance and neglect in not attending promptly to repairs when warning has been given.

Bangor, Me. H. H. Woodworth.

Horse Power of Compressors.

Editor The Practical Engineer:

In regard to H. L.'s question in the June number, I will answer him as I understand the question. By referring to a table of "horse power developed in compressing free air," I find that to compress 100 cubic feet of free air at 60 degrees temperature to 90 pounds gauge pressure requires 17.06 horse power. Now in H. L.'s statement, he says that 1900 cubic feet of air per minute were compressed to 90 pounds pressure when the engine was running at 92 revolutions and he wants to know what the horse power will be when the speed of the engine is changed to 74.5 revolutions per minute, which can be worked out as follows:

$$(17.06 \times 19) \times (74.5 \div 92) = 262.38$$

horse power.

This interpreted means that the 17.06 horse power, as found in the table to be necessary to compress 100 cubic feet of air to 90 pounds pressure, is multiplied by the number of hundreds of cubic feet of air compressed and this is again multiplied by the proportion between the revolution stated. The 262.38 horse power does not take into account the friction of the mechanism, but just simply gives the actual horse power required to do that amount of work. If an indicator was placed on the steam cylinder of the engine, the diagram would represent a higher power than that found by my calculation.

St. Louis, Mo. J. Tilden.

Is a License Law Needed in Canada?

The Canadian Manufacturer, while discussing the rejection of the Canadian license law by a committee of the Ontario Legislature, describes a case which is not unusual in many saw mills in this country. The case in point is as follows:

A few weeks ago, a boiler in a saw mill in the village of Staples, Ont., exploded, by which Ralph Welsh was killed and several other persons were more or less injured, some of whom have since died. Coroner McNiven and a jury investigated the matter, the general opinion of the witnesses being that the boiler was defective, and that a so-called accident had been expected for some time. The employees about the mill seemed to think that the boiler could withstand a pressure of 85 pounds of steam, but felt somewhat nervous when, shortly before the explosion, the engineer allowed the pressure to rise to 120 pounds. It was in evidence that when the boiler was repaired in March it could not be tested by hydrostatic pressure owing to the fact that some of the valves were leaking. D. R. Menzies, the manager of the mill, said that the boiler was in use when he assumed the management in 1894. About four years ago the mill was destroyed by fire, and when it was being rebuilt the boiler was repaired, and he was not aware that at the time of the explosion there was a weak spot in it. Fisher, the engineer in charge of the boiler at the time of the explosion, and who was fearfully injured, testified that he had worked there only about three weeks, and intended leaving. He had heard that the boiler had a bad reputation among the employees, who had occasionally fled from the mill, seeking places of safety, because of the action of the boiler when under extra high pressure. He had intended to clean the boiler while the mill was closed for the holiday. He was in front of the boiler when it exploded. He noticed that it was leaking just where it had been repaired. The safety-valve was supposed to blow off at a pressure of 95 pounds. Another employee, Larondot, testified that the pressure on the boiler indicated 122 pounds ten minutes before the explosion, and that he and David Boyd had taken French leave when the 115 pounds mark was reached. The coroner's jury decided that Ralph Welsh came to his death as a result of an explosion due to a defective boiler in a mill operated by the Neibergall Stave & Lumber Co.; and "we attach negligence on the part of said company for not providing adequate protection by testing the said boiler for the safety of their employees."

And still Mr. Stewart, secretary of the Canadian Manufacturers' Association, contends that there is no necessity or general demand for Government boiler inspection and the licensing of stationary engineers.

The highest concrete chimney ever built is located at Tacoma, Washington. It is 307 feet high and was designed for a smelter to carry away the deadly fumes developed in the reduction of the ores so that the surrounding vegetation will not be injured or the residents in the vicinity annoyed.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Speed of Belts. Cross-Compound Engine Receivers.

EDITOR THE PRACTICAL ENGINEER:

Can you give me a rule for calculating the speed of a belt per minute running on pulleys of different diameters?

I have an engineer's book which says that a cross-compound engine without a receiver must have its cranks set so that they will begin and end their strokes at the same time or be set at an angle of 180 degrees apart, but they don't give the reason. Why is it and why can't they be set at any angle of the stroke, just the same as if a receiver is used?

Fall River, Mass. J. R.

The rule for calculating the speed of a belt running on pulleys of different diameters is as follows: Multiply the diameter of the wheel by 3.1416, which gives the circumference and multiply this by the revolutions which the pulley makes per minute. This will give the speed of the belt per minute less any little slip which the belt might have.

A cross-compound engine must have a receiver because there must be some place into which the steam can exhaust from the high-pressure cylinder. Very often the receiver is the pipe through which the steam passes from the high- to the low-pressure cylinder. Engines that have their cranks set at 360 or 180 degrees apart do not require a receiver because the exhaust from one cylinder goes directly into the other cylinder, the admission port of the low-pressure cylinder being always open when the high-pressure cylinder is exhausting. This is not true when the cranks are at 90 or 270 degrees apart. At certain portions of the stroke, the low-pressure admission port is closed when the high-pressure cylinder is exhausting, so that some arrangement must be made for the exhaust steam until the low-pressure cylinder is ready for it. Engines, which have their cranks at 180 degrees, such as tandem-compound engines, while they do not need a receiver, sometimes use one for the purpose of getting rid of any moisture in the steam before it goes to the low-pressure cylinder, and also for reheating purposes.—[Ed.]

Power Required for Trolley Road.

EDITOR THE PRACTICAL ENGINEER:

We are thinking of building an electric road some twelve or fifteen miles long. There will not be any heavy grades and there will not be over three or four cars running at one time. Will you please tell me what size generator we would have to put in to furnish power enough? Would there not have to be a motor-generator placed between the station and the end of the line? What should be the size of this motor-generator? Would it not be best to use a high-tension alternator for the generator?

Cynthiana, Ky. J. S. J.

The amount of power required in the operation of a car depends upon many factors, such as the grades, size of cars, nature of service, etc.

With the kind of service mentioned on this road using light cars, it is probable that 35 horse power per car would be required, which would mean that about a 150 horse power generator for the road would be required. The maximum power required is in starting the car, so that it might happen that in a suburban road only a few amperes would be required per car for relatively long distances, in which case the output of the generator need not be so great. It is always a good thing, however, to have a generator large enough to take care of more cars when necessary, since it is to be expected that the road will grow and that there will often be unusual demands made upon it, such as all of the cars getting stalled on one hill.

As there are only a few cars on the line, it would be cheaper not to put in a motor-generator between the station and far end of the line, but instead, run a somewhat heavier feeder cable to the farthest point of distribution, the principal objection to a motor-generator for a small road being its cost. If, however, a motor-generator is used, which is done on many large lines, the size of the motor-generator would depend upon the number of cars in the section of the line which the motor-generator is to feed, so that the problem becomes more or less a problem of finance rather than that of engineering.

These same things apply to the use of a high-tension alternator because at the present time this alternating current would have to be transformed to 550 volts direct current, which would be a very expensive proposition for a small trolley line, although it is now being used in many of our large cities.

We would therefore say that, as we see the problem from this distance, it would perhaps be better to get at least a 200 kilowatt, 550 volt generator and use fairly large feeders. Since for long periods of time the amount of current used would be comparatively small, the amount of energy lost on the lines would not be very great. If, however, the road were to grow in size, this would become a very important matter.—[Ed.]

Segment of Circle Problem. Cooling Water Required for a Given Engine.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer the following:

(1). What is the height of a segment of a circle if the area of the segment in 547.2 square inches and the radius of the circle 26 inches? Kindly give a rule.

(2). How do you obtain the result to problem 3, submitted by A. E. W., Portland, Ore., which appeared in the April number?

Kansas City, Kansas. A. P.

(1). The rule for finding the height of a segment when the area and radius of the circle are given is as follows: Divide the area of the segment by the square of the diameter. The result will be a number which, when reference is made to a table of areas of segments, will give the percentage of the height of the segment compared to the diameter. Multiply this percentage by the diameter and the result will be the height

of the segment. In the above problem, the area of the segment is 547.2 square inches and when divided by the square of the diameter ($52 \times 52 = 2704$) gives .202 as a result. Referring to the table, it is found that when a segment has .202 for an area, the height of the segment is .305 times the diameter, which in this case gives $52 \times .305 = 15.86$ inches as the height of the segment. This problem, while a very interesting one in mathematics, is not one met with in practice.

(2). The problem referred to was as follows: An engine using a jet condenser develops 90 indicated horse power and uses 28 pounds of steam per horse power per hour. The terminal pressure in the cylinder is 3 pounds absolute and the temperature of the mingled steam and water is 125 degrees Fahr. What is the quantity of cooling water required, if the temperature of the cooling water is 60 degrees Fahr.?

This was worked out as follows:

Let W = weight of steam condensed.
w = weight of cooling water required.
T = temperature of steam.
t = temperature of cooling water.
t′ = temperature of mixture.
H = latent heat of evaporation.

Then, $W(T - t' + H) = w(t' - t)$, in which $W = 28 \times 90 = 2520$ pounds of steam per hour, and by referring to the steam table it is found that $T = 141.6$ degrees and $H = 1015.3$ heat units. Solving the equation becomes

$$2520(141.6 - 125 + 1015.3) = w(125 - 60)$$
$$2600388 = 65\ w$$
$$w = 40010$$

which is the number of pounds of cooling water required per hour.—[Ed.]

Three-Wire Systems.

EDITOR THE PRACTICAL ENGINEER:

(1). Is there any way that two three-wire systems can be run in parallel?

(2). In a three-wire system that gives 500 and 250 volts, how does the current flow?

Jackson, Mich. R. B.

(1). Two three-wire systems can be run in parallel if connected up as shown in sketch. Each of the two generators connected in series should have as near the same capacity and

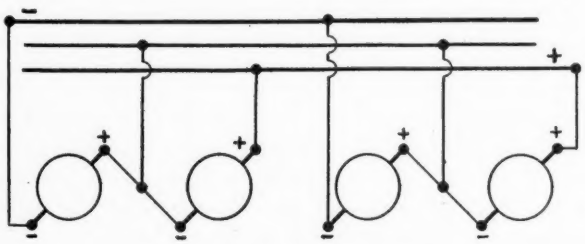


Fig. 1.—3-Wire Systems in Parallel.

same external characteristics as possible, which is true of all generators running the three-wire system, and the load on each side of the system should be as nearly balanced as possible.

(2). The current in any direct-current circuit flows from a high potential to that of a lower potential. This is just as true in a three-wire system as in any other. The sketch, Fig. 2, represents a three-wire system which will give 500 volts across the outside mains and 250 across the two adjacent mains. The current flows in the direction indicated by the arrows. If the same number of lamps were connected to each side of the sys-

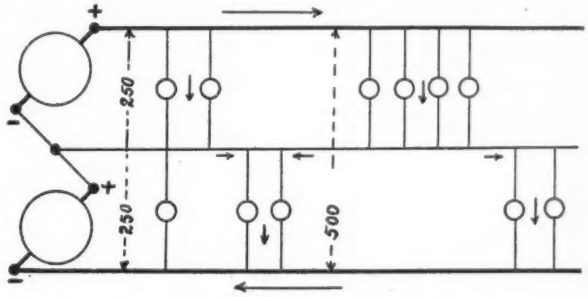


Fig. 2.—Direction of Current in 3-Wire System.

tem there would be no current in the middle wire except for short distances. If the current flowing through the outside mains is different, the difference between the two currents will represent the current flowing through the middle wire.—[Ed.]

Only Eleven Questions Asked by This Man.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer me the following questions:

(1). What is the maximum pressure per square inch allowed on a crank pin?

(2). What is the difference in the weight of air before and after passing through the flue of a boiler?

(3). How do you determine the safe speed of an eighteen-foot fly wheel, assuming the rim to weigh 20 tons?

(4). What per cent. of the steam is condensed by the cylinder walls of a simple non-condensing engine of about 100 horse power making 200 revolutions per minute?

(5). Describe and give three ways of plotting the theoretical steam curve. What is the adiabatic and isothermal curve?

(6). What are the several rules used in establishing the nominal factor of safety in boiler construction?

(7). Explain how factors of evaporation are found.

(8). A plain cylindrical boiler is 44 feet long and 52 inches in diameter. If the water line is 33 inches from the bottom of the boiler, what is the volume of water in the boiler?

(9). An air compressor cylinder contains 8.6 cubic feet of air at atmospheric pressure. When the air is compressed to a pressure of 623 pounds per square inch absolute, assuming the temperature to have remained constant, what percentage of the stroke has the piston completed?

(10). A shunt wound motor requires a current of 0.9 amperes at 500 volts when running free. The field resistance is 675 Ohms and the armature resistance is 2.5 Ohms. When the motor is taking 12.5 amperes at 500 volts, what is the output in watts and the efficiency? What is the field loss?

(11). A battery cell has an electro-motive force of 1.2 volts and a resistance of 0.8 Ohms, the resistance of the circuit is 1.1 Ohms, which arrangement will give the greater current, 20 cells in series or the same number in parallel? What is the electro-motive force of current and the total resistance in each case?

Buffalo, N. Y. J. N. T.

(1). The maximum pressure per square inch on a crank pin should never exceed 600 pounds per square inch of pro-

jected area, the area being the length of the bearing surface multiplied by the diameter of the pin.

(2). The weight of a cubic foot of air at 60 degrees is .076 pounds. At 500 degrees, an average temperature of flue gases, it will be .042 pounds per cubic foot.

(3). As 6000 feet per minute is the maximum velocity of rim allowable, then if D = diameter of the wheel in feet and R = number of revolutions per minute, D = 6000 ÷ 3.1416 R. Substituting for D its value 20 feet, R equals 95 revolutions per minute, which gives the maximum safe speed allowable.

(4). This depends upon the cut-off and the range of temperature through which the steam passes. With a simple engine, as mentioned in the question above, the cylinder condensation would vary between 5 and 40 per cent., depending upon whether cut-off took place at ½ stroke or 1-20th stroke.

(5). Three methods of finding the theoretical steam curve are shown in Figs. 1, 2 and 3. In Fig. 1, the line AB represents the admission line, and line BC the steam line. C is assumed as the point of cut-off and the line AE is line of zero pressure.

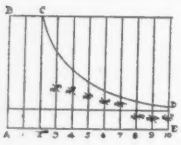


Fig 1.

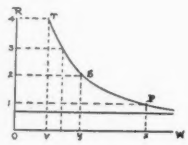


Fig. 2.

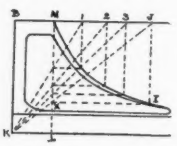


Fig. 3.

Dividing the line AE into 10 parts, and since the line 2 passes through C, the pressure on line 3 is made 2-3rds of AB, line 4 is made 2-4ths of line AB, line 5 is laid off 2-5ths of AB and so on, the curve CD joining the points, being the theoretical curve from the point of cut-off. Fig. 2 represents another method. Any point such a P is selected on the expansion line and P1 and Px are drawn perpendicular to the zero volume and zero pressure lines respectively. Oy is made ½ Ox and O2 is twice O1 and the intersection of the perpendiculars at S is another point on the curve. To get any other point it is only necessary to fulfill the condition that the product of the distances from the two lines OR and OW is always constant. A third method is shown in Fig. 3. Select any point I in the actual curve and from this point draw a line perpendicular to the line JB, as JI. The line JB is usually made equal to the boiler pressure. From J draw a line diagonal to K, the intersection of the vacuum and clearance lines. From I draw Ix parallel to the atmospheric line. From the point x, which is the intersection of JK and Ix, draw the vertical line LM. The point M is the theoretical point of cut-off and LM the cut-off line. Take any number of points, such as 1, 2, 3 on the line JB, and from these points draw diagonals to K. From the intersection of these diagonals with LM draw horizontal lines and from 1, 2 and 3 draw vertical lines. Where these lines meet will be points on the hyperbolic curve.

An adiabatic curve is the expansion curve of a gas which assumes that there is no transmission of heat during expansion. An isothermal curve assumes that the temperature of the gas is kept constant during expansion, in which case the volume varies inversely as its pressure.

(6). A factor of safety of 5 is usually allowed; that is, one-fifth of the breaking pressure of the weakest part is taken as the working pressure.

(7). The factor of evaporation can be obtained from the formula $(H - h) \div 966$ in which H is the total heat of the steam at boiler pressure and h is the total heat of feed water at its average temperature.

(8). The volume of water in the boiler assuming that there is no space taken up by tubes is 479.6 cubic feet.

(9). Length of stroke should be given before this can be answered.

(10). Useful work given out in watts would be 5700; efficiency 91 per cent. The field loss is 370 watts.

(11). In this special case, the grouping of the cells in series will give the most current. When in series the electro-motive force of the 20 cells will be 24 volts and current flowing through the external circuit will be 1.4 amperes. When in parallel the voltage of the cells will be 1.2 volts and the current passing through the external circuit will be 1.05 amperes. In making these calculations the formula for the divided circuit must be used.—[Ed.]

Gasoline Engine Ignition.

EDITOR THE PRACTICAL ENGINEER:

Kindly inform me if a gasoline engine will run all right by using current from electric light wires in place of a battery?

Hanover. R. J. L.

Direct current from a dynamo is used extensively for ignition, as it avoids all care and trouble which is likely to arise from a battery. Care must be taken, however, in connecting to the circuit that it passes through suitable resistance, so that when contact is made it will not short-circuit the system. A current of about 2 amperes will give good results.—[Ed.]

Efficiencies of Riveted Joints. Leaky Exhaust Valve. Maximum Pump Pressure. Old Boilers.

EDITOR THE PRACTICAL ENGINEER:

(1). Will you please give me the rule for finding the efficiency of a single and double riveted lap joint; also for a double riveted butt strap joint?

(2). Will you also show me a card with a leaky exhaust valve? What effect will it have upon the mean effective pressure?

(3). At what water pressure will a pump stop which has a 10-inch water piston and an 8-inch steam piston, if the steam pressure is 100 pounds per square inch?

(4). If a boiler was 25 years old and the plates as thick as when new and having the same tensile strength, why should the pressure be reduced?

Roxbury, Mass. W. C. H.

(1). The efficiency of a riveted joint is the strength of the plate compared with the strength of the joint when it is riveted. The best method for finding the efficiency is with a testing machine, by means of which a specimen of the plate and a riveted joint may be torn apart and their strength compared. The efficiency of a riveted joint can also be calculated but the diameter and pitch of the rivets must be known, and the strength and thickness of the boiler plate.

The strength of a single riveted lap joint may be calculated as follows: Assume the plate to be ¼-inch thick and to have a tensile strength of 55,000 pounds per square inch, the pitch of the rivets being 2 inches and the upset diameter of the rivets

$^{11}/_{16}$ of an inch, the shearing strength of a steel rivet being 44,600 pounds per square inch then,

Section of plate.....2 inches × .25 = .500 sq. inch.
Section removed by hole....6875 × .25 = .172 " "

Net section of plate between holes..... .328 " "
Area of upset rivet.....$^{11}/_{16}$ inch = .372 " "
Shearing strength of rivet at 44,600 pounds per square inch 16,591
Shearing strength of plate.....0.5 × 55,000 = 27,500
Shearing strength after punching, .328 × 55,000 = 18,045

The efficiency of the joint, since the shearing strength of the rivet is less than the strength of the plate between the rivets, is

$$\frac{16,591}{27,500} = 60 \text{ per cent.}$$

The efficiency of a double-riveted lap-joint is obtained in a similar manner. Assume the plates to be ¼-inch thick, having a tensile strength of 55,000 pounds per square inch; suppose the rivets to be made of iron $^{11}/_{16}$-inch in diameter which have a shearing strength of 34,200 pounds per square inch and a pitch of 2.5 inches, then,

Strength of whole plate = 2.5 × .25 × 55,000 = 34,375 pounds.
Strength of net section = (2.5 — .6875) × .25 × 55,000 = 24,915 pounds.
Strength of two rivets in single shear = .372 × 2 × 34,200 = 25,444 pounds.

The strength of the plate being weaker in this case than the strength of the rivets, the efficiency becomes

$$\frac{24,915}{34,375} = 72.48 \text{ per cent.}$$

The efficiency of a double riveted butt-joint can be obtained as follows: Assume thickness of plate, ⅝-inch; diameter of upset rivet, 1 inch; pitch of rivets, 4 inches.

The strength of the whole plate = 4 × .625 × 55,000 = 137,500.
Strength of net section of plate = (4 — 1) × .625 × 55,000 = 103,125.
Strength of two steel rivets in double shear would be 4 × 34,200 × 2 = 273,600.

The strength of the rivets being therefore greater than the net strength of the plate, the efficiency becomes

$$\frac{103,125}{137,500} = 75 \text{ per cent.}$$

(2). The effect of a leaky exhaust valve upon an indicator diagram is not often apparent. Its tendency, however, is to lessen the pressure in the cylinder. If the expansion line of the engine was recorded, when the exhaust valves were known to be tight, and compared with an expansion line of an indicator diagram taken while the exhaust valves were leaky, it will be found that the expansion line of the leaky card will fall below the expansion line of the true card. Its effect upon the compression line is very similar although it can usually be more easily detected in this line. Its effect upon the mean effective pressure would be to reduce it, although it might happen that owing to the reduction of the compression pressure, the area of the card would not be perceptibly reduced. One of the principal effects which a leaky exhaust valve has, is to increase the steam consumption per horse power.

(3). Disregarding internal friction, the amount of work which a pump is capable of doing is proportional to the square of the diameters of the cylinders, so that with the given conditions the pump could not possibly pump a greater pressure than 64 pounds per square inch. Owing to the loss of power within the pump, it is doubtful whether a greater pressure than 55 pounds could be realized.

(4). If a boiler was as strong after 25 years of use as it was the day it was installed, there would be no reason for reducing the pressure. This is, however, seldom the case, and even if deterioration is not noticeable there may be some part of the boiler which may have suffered from its long use. It is also claimed by many experts that if a boiler plate has been in use for many years, the constant expansion and contraction of the metal will materially reduce its tensile strength even though its thickness is the same as when new. In order, therefore, to be on the side of safety, it is usual and proper to reduce the boiler pressure of an old boiler.—[Ed.]

The Dunham Steam Trap.

Simplicity with absolute efficiency has been the aim of steam trap manufacturers ever since the first conception of a steam trap, and at different times steam traps have been placed upon the market, each having some especial claim upon these two features. Three years ago a novel steam trap was placed upon the market by a Western manufacturer, known as the Dunham Steam Trap, which was claimed to combine these two features in an exceptional degree. Since that time the success of this trap has been unusual.

The Dunham trap is of the expansion type. There are no floats, springs, levers, pots or buckets to get out of order, nor any hinged joints to gum and stick, causing retarded action. Its motive force is a volatile fluid contained in a disc of high-grade metal, which vaporizes and expands and contracts the walls under varied pressures and temperatures governing the movement of the valve, according to the amount of condensation given off. The trap acts instantly, due to the fact that only a small quantity of fluid is placed in the diaphragm, and any change of temperature causes it either to flash into a vapor, developing a pressure which closes the valve, or, on the other hand, to condense, creating a vacuum which draws it open.

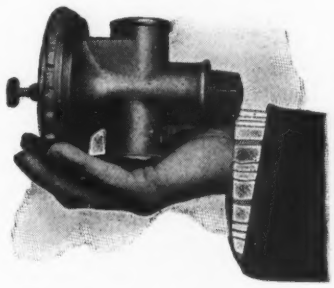


Fig. 1.

The Dunham trap is constructed wholly of phosphor-bronze, which has excellent wearing qualities and is unaffected by alkaline or acid waters, such as corrode iron. It is a trap of few parts—the trap body, diaphragm, valve stem, cap and plug, all of which are made upon special machines to insure uniform size and interchangeability.

Fig. 1 represents the one-inch size, which is so small that it may be held in the hand. This size has a capacity for draining 10,000 lineal feet of one-inch pipe, and for this reason it is called "the smallest trap with the largest capacity of any trap in the world."

Fig. 2 represents the trap assembled, from which an understanding of its operation may be obtained. It also shows the

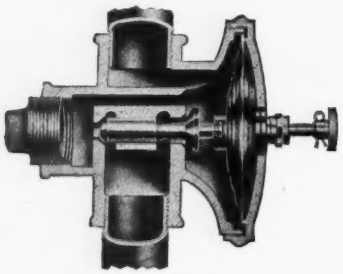


Fig. 2.

simplicity of the trap and also indicates its positive action. The valve stem is hooked onto the diaphragm by a special arrangement which insures the advantage of the whole contractive movement. The disc is made of the best grade of metal obtainable and is stamped out with special regard for its elastic strength. To insure uniform expansion of the disc, it is corrugated—a very important provision. Each diaphragm, or disc, is brazed at its edges by a process which is original with this company, and made positively and permanently tight and braced against any unusual collapsing strain. Under ordinary conditions these discs will last many years, and are fully guaranteed.

The trap is easily inspected and no pipe connections need be broken. The cover may be screwed off by hand after cooling off with water. The diaphragm valves are then free to be removed. The valve seats may be reground without removing the trap from its position on the pipe by simply placing an ordinary brace over the valve steam and revolving it until the

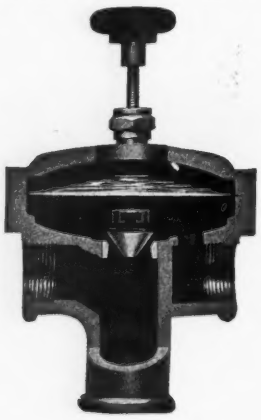


Fig. 3.

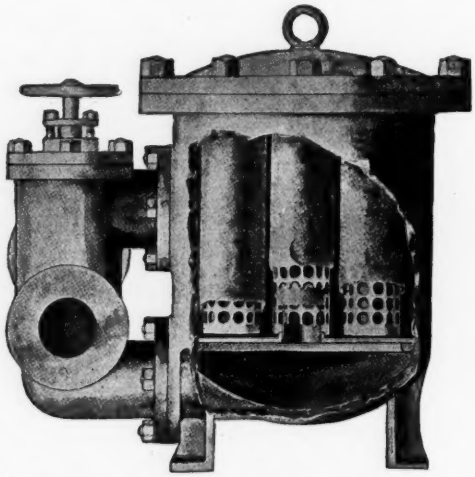
valve is perfectly tight, as will be indicated by the bright surfaces on each face.

The Dunham Trap is also made in cast iron for heating work and oil separators, as shown in Fig. 3. This style of trap has a large valve opening area and a settling pocket for scale, steam can never pass the trap but, on the other hand, it is always open for water and air either on pressure or vacuum heating system. They can be placed upon heating returns that connect direct to the suction of the pump, eliminating any receiving tank, and at the same time preventing steam getting into the pump suction.

These traps are manufactured by C. A. Dunham Company, Marshalltown, Iowa; Philadelphia Agent, L. Bancroft Mellor, 14 S. Fourth Street.

The Blackburn Smith Patent Feed Water Filter and Grease Extractor.

The durability of a boiler depends to a large extent upon the kind of feed water used. Repairs are reduced to a minimum if clean water and ordinary attention are given a boiler, but the moment grease finds its way in, on account of its being such a bad conductor of heat, trouble and repairs usually begin.



The Blackburne Smith Feed Water Filter and Grease Extractor.

Where surface condensers are used and the water resulting from the condensing of the exhaust steam returned to the boilers, the feed water must be purified before being used because the exhaust steam contains the oil and grease used for lubricating the pistons, rods, valve and valve stems and dirt and wear from the cylinder and valves. This mixture is condensed and pumped to the hot well and unless filtered before entering the boiler it will be very likely to cause leaky tubes, corrosion, pitting, foaming or other detrimental effects.

Among the various methods which are being used for keeping oil out of boilers, one that insures a positive separation is that of filtration of the feed water. With this method the water is forced through a filtering medium which will effectively absorb or prevent all foreign matter from passing. The efficiency of any separating surface or medium is very much decreased when it becomes covered with oil so that any apparatus which can be cleaned easily represents a marked improvement.

The Blackburn Smith Patent Feed Water Filter and Grease Extractor, manufactured by the Greacen-Derby Engineering Co., of Perth Amboy, N. J., is shown in the accompanying illustration and represents a type of filter and grease extractor which embodies the above-mentioned principles. They are being used for oil, mud or sand separation, for steamships, tug boats, yachts, electric power and factory plants and for office buildings, sugar refineries and water works.

The Blackburn Smith Filters are double filtration and are fitted with an inlet valve, outlet valve, sludge valve, relief valve, by-pass, steam cleaning valve, two pressure gauges, companion flanges and complete spare set of filtering cartridges. The spare cartridges are kept handy and ready for insertion.

To clean the filter it is simply necessary to by-pass the feed water by moving the valve. The filter chest is then shut off and the cover can be taken off, foul cartridges lifted out and the clean spare set inserted. All cartridges are made of solid drawn brass tubing, perforated by drilling. The rotary valves are made of composition and ground into a perfect fit. The entire filtering arrangement and all fittings are of composition.

The Gemmell Patent Boiler.

The upright boiler in many respects possesses a number of advantages over the boiler of the horizontal type because it is light and portable, it requires no setting, it is a rapid steamer, it takes little floor space, and it affords a natural path for the flue gases.

The Gemmell Patent Boiler is an upright boiler which possesses not only all the above features of the upright boiler but which, by its arrangement of tubes, possesses all the advantages of the horizontal type. The improvement in the construction increases the efficiency, by the rapid circulating and evaporating of the water. This circulation is attained by means of the circulating tube in the fire-box above the grate bars; by carrying off the gases to a lateral smoke-box on the front of the boiler; and by means of horizontal flues in place of the old method of carrying off the gases through upright flues which extend from the crown sheet to the upper head.

The accompanying illustrations, Fig. 1 and Fig. 2, will show how these objects have been attained. Fig. 1 is a vertical section of the boiler. A is a circulating water tube which passes over the fire-box in an inclined position and is flanged and

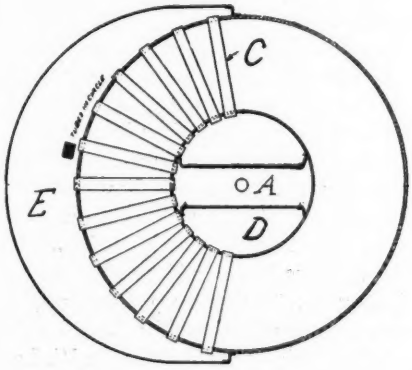


Fig. 2.

riveted to fire-box B. The horizontal tubes C, extend from the combustion chamber D, to smoke-box E, as shown, and the cleaning doors are located at F.

Fig. 2 represents a horizontal section of the boiler and more clearly shows the arrangement of the tubes C. They are expanded and beaded into the fire-box and into the outer shell. The smoke-box is again shown at E, the smoke-stack being attached to the front of the boiler by angle irons and provided with cleaning doors.

By this arrangement, the flames and gases are in direct contact with an unobstructed dished crown sheet and are deflected by this crown sheet to the horizontal flues, through which they travel to the smoke-box. The smoke and gases are thus consumed, so that when the consumed gases reach the smoke-stack, they are at a low enough temperature not to burn out the smoke-stack and tubes.

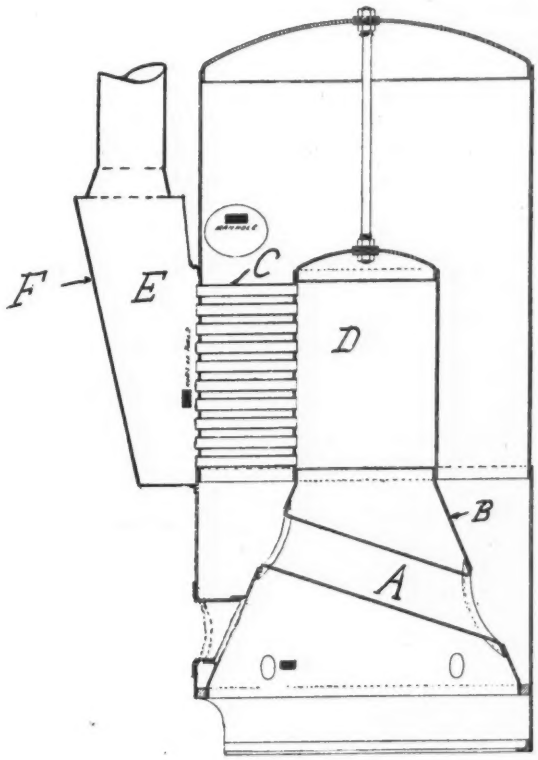


Fig. 1.

The Gemmell Patent Boiler is manufactured by the General Engineering Co., 764 S. Swanson St., Philadelphia, Pa., who claim that it is capable of giving out 5 horse power per square foot of grate surface; that it will burn 18 pounds of coal per square foot of grate surface per hour; and that it will evaporate 12 pounds of water per pound of coal. Other advantages claimed for it are its low first cost and low cost of repairs, its accessibility and the small size of fire room required, a room 10 x 15 feet being of sufficient size for a 100 horse power boiler.

Fifth Annul Convention of the N. A. S. E. Wisconsin State Association.

The fifth annual convention of the Wisconsin State Association of Stationary Engineers convened in the city of Madison on the morning of June 17, 1905, with a full attendance. Mr. Peter Gauer, Chairman of the Committee of Arrangements, introduced Mr. W. D. Curtis, Mayor of the city, who in behalf of the city of Madison welcomed the engineers to the city. Mr. I. H. Crawford, President of the State Association, responded to the Mayor's address and Mr. H. J. Optenberg, of Sheboygan, gave an interesting talk. Chairman Gauer then turned over the gavel to President Crawford, when the regular business was transacted.

The convention adjourned for a trolley ride to the Northern Electrical Mfg. Co.'s shops, where the delegates inspected the works and an hour was passed in seeing the manner in which the dynamo is made and assembled.

The convention was again called to order in the afternoon. An exhaustive report was made by J. A. Wickert, Chairman of the State License Committee. The result of all the hard work done was "no license," but it was predicted that the time will come when such a law will be found on the statute books of Wisconsin and when once there, every manufacturer and engineer in Wisconsin will rejoice.

The following officers were re-elected for the ensuing year: President, I. H. Crawford, of Oshkosh, No. 9; Vice-President, Martin O'Connor, of Milwaukee, No. 1; Secretary, Fred. A. Bloom, of Racine, No. 3, and Treasurer, Anton Pfaller, of Milwaukee, No. 7. The new officers elected were: Conductor, Dan. Dredger, of Manitowa, No. 4, and Doorkeeper, J. H. Optenberg, of Sheboygan, No. 2.

After passing resolutions thanking Wisconsin, No. 14, for their courteous entertainment and kind treatment, the convention adjourned to meet at Manitowoc on June 16, 1906.

Among the exhibitors represented were: Jenkins Bros., with B. W. Darling in charge of a display of valves and packing; Chapman Valve Co., with W. L. Buss in charge of their valve display; H. W. Johns-Manville, with P. L. Griffith in charge of pipe covering exhibit; Garlock Packing Co., with Mr. C. W. Owens in evidence; Crandall Packing Co., with Mr. M. V. Burlington doing the honors, and the Dearborn Drug and Chemical Works, with E. T. Ward in charge of exhibit.

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State Convention of the Massachusetts N. A. S. E.

The Massachusetts State Association of the N. A. S. E. held one of their most successful conventions at Fall River, Mass., on Friday, July 7th and Saturday, July 8th. The session on Friday afternoon was devoted entirely to the consideration of business and the election of officers. Past President William E. Bradbury presided and Mayor Coughlin welcomed the delegates in a brief and pleasant speech.

Among the important business transacted was the acceptance of the report of the licence committee. This committee reported on the passage of the new license law by the last Legislature. This law, which has heretofore been printed, makes a few important changes in the old law. It provides that engineers making application for a license shall give their experience under oath, and wilful misrepresentations shall be punishable; that second-class engineers may operate first-class plants under the direct supervision of a chief engineer; and that the district police shall have authority to enter any steam plant at any time. The committee also reported that another bill had been passed providing for the inspection of all boilers over three horse power. A vote of thanks was tendered the committee.

The election of officers resulted as follows: President, Fred. L. Johnson, of Lynn; Vice-President, Eli Howarth, of Fall River; Secretary, Ole B. Peterson, of Roxbury; Treasurer, Walter H. Damon, of Springfield. These officers were installed by Past President James Duncan, of Boston.

In the evening, the members of Troy Association, the local association, tendered a dinner to 260 stationary engineers and their friends at Music Hall. The most prominent guests were seated on the stage. Mr. Charles N. Bowen presided as toastmaster and on behalf of the Association welcomed the delegates to the city. He first called upon F. L. Johnson, the newly-elected president of the State Association, who in a few words thanked the Association for his election and referred to the engineer as a professional workingman. He said that by a proper knowledge the engineer was able to increase the value of his services to his employer and by his knowledge he is able to reduce the toil of his fellow-men, making him a public benefactor. The Optimus Quartette was next introduced and rendered several selections, which were heartily applauded.

Toastmaster Bowen then called upon Mayor Coughlin, who referred to the great improvement made in the past few years in the mechanical arts and how this had displaced much manual labor. He referred to the multiplicity of patents issued from Washington and thought it was a good sign. He expressed his pleasure at being present and extended the freedom of the city to all the delegates and urged them to enjoy themselves to the fullest measure.

State Deputy T. N. Kelsey, of Lowell, addressed the gathering and spoke of the careful study by the engineers for the purpose of understanding and meeting the wishes of their employers. He believed that by reason of study the engineer of tomorrow would be far superior to the engineer of today, as the engineer of today is above the engineer of 25 years ago.

Another speaker was National Past President P. H. Hogan, of Boston, an easy and interesting speaker. He congratulated the State Association upon the number of delegates present and referred briefly to the history of the State Association organized 23 years ago and the local branch organized nine years ago in the hall in which he was speaking. He was glad to see the leaders of that movement still in the ranks. He predicted that in another year the National Association would reach the 20,000 mark. The rest of the evening was taken up by songs and stories, the dinner closing with the singing of "Auld Lang-Syne."

On Saturday morning, the visiting delegates were taken in charge by members of the local committee and on special cars paid visits to some of the larger steam plants in the city. The first stop was made at the Fall River Iron Works mills where the delegates were met by Supt. Hathaway and shown through the magnificent plant. After a short stay the party went to the King Philip brewery, of which an exceedingly thorough inspection was made. The last place visited was the Flint mills.

The following firms had exhibits at the convention: Keystone Lubricating Co., The Sims Co., The Lagonda M'f'g Co., Jenkins Bros., Patterson Lubricating Co., Philadelphia Grease M'f'g Co., Burke Engineering Co., George W. Lord Company, Garlock Packing Co., Geo. W. Knowlton Rubber Co., American Steam Gauge and Valve Co., Ashton Valve Co., Challenge Tube Cleaner Co., The Wm. Powell Co., James L. Bobertson & Sons, L. J. Bordo, Nathan Miller, John F. Johnston Co., Dearborn Drug & Chemical Works, Nason Regulator Co., International Correspondence School, Cling Surface M'f'g Co., A. W. Chesterton & Co., Holmes Metallic Packing Co., Williams Gauge Co., Lippincott Steam Specialty and Supply Co., and Indicator Instruction Co. Interesting souvenirs were given out by the Dearborn Drug and Chemical Works, Patterson Lubricating Co., and the Keystone Lubricator Co.

The next convention will be held at Newburyport, Mass.